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Scientists and Their Gods

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Paper of Content

1. Introduction

I first began teaching freshman chemistry at Berkeley in the spring of 1984. The physical sciences lecture hall at Berkeley holds about 550 persons. On the first day of class you could fit in 680 students, which we had on that particular morning. It was a very full auditorium. Those of you who have had freshman chemistry at a large university will know that many have mixed feelings about such courses. I had never addressed a group of 680 people before and was a bit concerned about it. But I had a fantastic demonstration prepared for them.

At Berkeley in the physical sciences lecture hall, the stage is divided into three parts. It rotates around, so you can go to your part of the stage and work for two hours before your lecture, getting everything ready. My assistant, Lonny Martin, who still does the undergraduate chemistry demonstrations at Berkeley, was behind the stage in the process of setting up ten moles of a large number of common chemical quantities. Ten moles of benzene, iron, mercury, ethyl alcohol, water, etc. At just the right time, at the grand crescendo of this lecture, I was going to press the stage button and Lonny would unexpectedly rotate into view and show the students the ten moles of various items. The students would have a moment of enlightenment as they realized that each displayed quantity of these chemical substances had the same number of molecules, namely ten times Avogadro's number.

It was going to be wonderful. We got to the critical point in the lecture and I said, "Lonny, come around and show us the moles." I pressed the button to rotate the stage but nothing happened. I didn't realize that Lonny was overriding my button press because he wasn't ready with the moles. This was very embarrassing. I went out in front of the 680 students and was really at a complete loss of what to say, so I made some unprepared remarks. I said, "While we're waiting for the moles, let me tell you what happened to me in church yesterday morning." I was desperate. There was great silence among those 680 students. They had come with all manner of anticipations about freshman chemistry, but stories about church were not among them!

At least as surprised as the students, I continued, "Let me tell you what my Sunday School teacher said yesterday." The students became very quiet. "I was hoping the group at church would give me some support, moral, spiritual, or whatever, for dealing with this large class, but I received none. In fact, the Sunday School teacher first told anecdotes about his own freshman chemistry instructor, who kicked the dog, beat his wife, and so on. Then he asked the class, in honor of me:

'What is the difference between a dead dog lying in the middle of the street and a dead chemistry professor lying in the middle of the street?'"

The class was excited about this and I hadn't even gotten to the punch line. They roared with laughter. The very concept of a dead chemistry professor lying in the middle of the street was hilarious to them. I'm sure some of them began to think, "If this guy were to become a dead chemistry professor very close to the final exam, we probably wouldn't have to take the final exam. Berkeley would probably give us all passing grades, and this would be wonderful."

Then I told the students that my Sunday school teacher had said that the difference between a dead dog lying in the middle of the road and a dead chemistry professor lying in the middle of the road is that there are skid marks in front of the dead dog. It was a new joke at the time, and the class thought it was outstanding! Just as they settled down, I pressed the button and around came Lonny with the moles. It was an extraordinary beginning to my career as a freshman chemistry lecturer.

About 50 students came down to the front of the auditorium at the end of class. About half had the usual questions like "Which dot do I punch out of this registration card?" There is always some of that. But about half of these students had related questions. Basically they wanted to know "What were you doing in church yesterday?" One in particular said, "The person I have most admired in my life to date was my high school chemistry teacher last year. He told me with great certainty that it was impossible to be a practicing chemist and a Christian. What do you think about that?" I responded briefly, but we didn't have time for a lengthy discussion. However, some of the other students who were listening in asked me if I would give a public lecture on this topic. That was the origin of the present essay.

I gave this talk in Berkeley, at Stanford University, and in the San Francisco Bay Area a number of times. The lectures were well attended and mildly controversial. One of the local newspapers ran a substantial story (April 19, 1986) on the Stanford lecture, given at an American Scientific Affiliation symposium "God and Modern Science: Who Shapes Whom?" The author of this particular story titled it "Science and Religion: Chemist an Exception." As you will see if you read on, this conclusion was quite the opposite of the picture I had attempted to draw in my lecture. The lecture was also given to a modest audience at Brown University (1985), to a large audience at the University of Canterbury, Christchurch, New Zealand (1986), and to an audience of five brave souls at the University of Kansas (1986; a return trip to the University of Kansas drew an audience of 200 in April, 2000).

When I moved to the University of Georgia in late 1987, the level of interest in these lectures increased dramatically. In large part this was because some faculty members complained to the University of Georgia administration. It was an interesting chapter in my life. The Atlanta Journal and Constitution, the largest newspaper in the southeastern United States, ran a front page story on October 23 entitled "UGA Science Prof's Lectures Prove Volatile Brew." These hostile faculty members were of the opinion that it was unconstitutional for anyone to use a vacant university classroom to discuss the relationship between science and religion. A few days later my sister-in-law called from Seattle, saying that she had heard on the radio that I was being fired for preaching in the classroom! In fact, I had yet to teach my first class at the University of Georgia. Moreover, the President of the University of Georgia, Dr. Charles B. Knapp, swiftly came to my defense. Dr. Knapp stated to the press "This kind of intellectual ferment is good for the place. I think it's an exercise of his freedom of speech." And on Saturday morning October 31, the Atlanta Journal and Constitution published an editorial supporting me. The AJC stated "Fanatics are demanding rigorous control over the dissemination of ideas. . . . University officials have had the good sense - and the courage - to resist. They must continue to do so." The Athens, Georgia (a city of 100,000) newspapers also came to my defense and a "street poll" conducted by the media indicated that virtually all the students on the University of Georgia campus viewed the issue as a matter of freedom of speech. Lesser headlines followed, the most creative appearing in the January 10, 1988 edition of the Savannah Morning News/Evening Press: "Chemistry Prof's Bible Lectures Explosive."

2. Scientists and Their Gods

A Perspective on the Relation between Science and Christianity

Many educated people are of the opinion that there has been a terrible warfare between science and Christianity. Let us attempt to put this question of the relationship between science and Christianity in the broadest, most reasonable perspective possible. We begin by noting that the rapprochement between science and other intellectual pursuits has not always been easy. For example, the recent text "Literature" by Susan Gallagher and Roger Lundin states:

"Because in recent history, literature has often found itself in opposition to science, to understand modern views about literature, we must recognize the dominance of science in our culture. For several centuries, scientists have set the standards of truth for Western culture. And their undeniable usefulness in helping us organize, analyze, and manipulate facts has given them an unprecedented importance in modern society."

For example, John Keats, the great English romantic poet, did not like Isaac Newton's view of reality. He said it threatened to destroy all the beauty in the universe. He feared that a world in which myths and poetic visions had vanished would become a barren and uninviting place. In his poem "Lamia," he talks about this destructive power. In this poem, he calls "science" "philosophy", so I will try to replace the word "philosophy" with "science" so as not to confuse the 21st century reader:

"Do not all charms fly At the mere touch of cold science? There was an awful rainbow once in heaven We knew her woof, her texture. She is given in the dull catalog of common things. Science will clip an angel's wings, Conquer all mysteries by rule and line, Empty the haunted air and gnomed mine, Unweave a rainbow."

My point is that there has been friction between science and virtually every other intellectual endeavor, since the appearance of modern science as a newcomer on the scene around 1600. So it would be surprising if there were not some heated exchanges between science and Christianity. What I am describing is called "The new kid on the block" syndrome in colloquial North American English.

Has Science Disproved God?

Nevertheless, the position is commonly stated that "science has disproved God." C. S. Lewis says, in the autobiography of his early life, "Surprised by Joy," that he believed the above statement. He talks about the atheism of his early youth and credits it to science. Lewis writes:

"You will understand that my (atheism) was inevitably based on what I believed to be the findings of the sciences; and those findings, not being a scientist, I had to take on trust, in fact, on authority."

What the author is saying is that somebody told him that science had disproved God; and he believed it, even though he knew nothing about science.

A more balanced view of this question was given by one of my scientific heroes, Erwin Schroedinger (1887-1961). He was perhaps the most important of the founders of wave mechanics and the originator of what is now the most important equation in science, Schrodinger's Equation. Schroedinger declares:

"I'm very astonished that the scientific picture of the real world is very deficient. It gives a lot of factual information, puts all our experience in a magnificently consistent order, but it is ghastly silent about all and sundry that is really near to our heart, that really

matters to us. It cannot tell us a word about red and blue, bitter and sweet, physical pain and physical delight, knows nothing of beautiful and ugly, good or bad, God and eternity. Science sometimes pretends to answer questions in these domains, but the answers are very often so silly that we are not inclined to take them seriously." From "Nature and the Greeks," Cambridge University Press, 1954.

Scientists do tell some interesting stories about religion. This one is from "Chemistry in Britain", which is something like the "Time" magazine of the chemical profession in England. Talking about the release of a new book on science policy, "Chemistry in Britain" (July, 1989) explores an interesting idea:

"If God applied to the government for a research grant for the development of a heaven and an earth, He would be turned down on the following grounds:

* His project is too ambitious; * He has no previous track record; * His only publication is a book, not a paper in a refereed journal; * He refuses to collaborate with his biggest competitor; * His proposal for a heaven and an earth is all up in the air."

Some Alternatives to Belief in the Sovereign God of the Universe

I present here examples of two notable atheists. The first is Lev Landau, the most brilliant Soviet physicist of the twentieth century. Landau received the 1962 Nobel Prize in Physics for his research on liquid helium. Moreover, Landau was named a Hero of Socialist Labor by the Soviet government. He was also the author of many famous physics textbooks with his coworker E. M. Lifshitz. I used some of these books as an undergraduate at M.I.T. A story about Landau by his good friend and biographer I.M. Khalatnikov, appeared in the May 1989 issue of "Physics Today." Khalatnikov writes:

"The last time I saw Landau was in 1968 after he had undergone an operation. His health had greatly deteriorated. Lifshitz and I were summoned by the hospital. We were informed that there was practically no chance he could be saved. When I entered his ward, Landau was lying on his side, his face turned to the wall. He heard my steps, turned his head, and said, 'Khalat, please save me.' Those were the last words I heard from Landau. He died that night."

The second example is Subrahmanyan Chandrasekhar,the famous astrophysicist who won the Nobel Prize in Physics in 1983. He was a faculty member at the University of Chicago for most of his life. At the back of his biography is an unusual interview. Chandrasekhar begins the dialogue, saying:

"In fact, I consider myself an atheist. But I have a feeling of disappointment because the hope for contentment and a peaceful outlook on life as the result of pursuing a goal has remained largely unfulfilled."

His biographer, K. C. Wali, is astonished and responds:

"What?! I don't understand. You mean, single-minded pursuit of science, understanding parts of nature and comprehending nature with such enormous success still leaves you with a feeling of discontentment?"

Chandrasekhar continues in a serious way, saying:

"I don't really have a sense of fulfillment. All I have done seems to not be very much."

The biographer seeks to lighten up the discussion a little, saying that everybody has the same sort of feelings. But Chandrasekhar will not let him escape, saying:

"Well it may be. But the fact that other people experience it doesn't change the fact that one is experiencing it. It doesn't become less personal on that account."

And Chandrasekhar's final statement, which I urge every potential young scientist to ponder:

"What is true from my own personal case is that I simply don't have that sense of harmony which I had hoped for when I was young. And I have persevered in science for over fifty years. The time I have devoted to other things is miniscule."

From K. C. Wali, "Chandra: A Biography of S. Chandrasekhar" (University of Chicago Press, 1991).

Is it Possible to be a Scientist and a Christian?

So the question I want to explore is the one that I was asked by that young man after my first freshman chemistry class at Berkeley, "Is it possible to be a scientist and a Christian?" The student and his high school chemistry teacher obviously thought it was not possible.

Let me begin from what some might call neutral ground by quoting two people with no particular theistic inclinations. The first individual is C. P. Snow (1905-1980). C. P. Snow remains well known in intellectual circles as the author of an essay titled "The Two Cultures and the Scientific Revolution." C. P. Snow was a physical chemist, actually a spectroscopist, at Cambridge University. He discovered about halfway through his career that he also was a gifted writer, and Snow began writing novels. One in particular about university life at Cambridge or Oxford is called "The Masters," and I would recommend it. C. P. Snow became quite comfortable with the royalties from his novels and was able to sit in a unique position between the world of the sciences and the world of literature. From this perspective, Snow wrote:

"Statistically, I suppose, slightly more scientists are in religious terms unbelievers, compared with the rest of the intellectual world, though there are plenty who are religious, and that seems to be increasingly so among the young."

So, is it possible to be a scientist and a Christian? C.P. Snow answered in the affirmative.

Richard Feynman (1918-1988), Nobel Prize in Physics in 1965, was a most remarkable person. Perhaps some of you have read his book of anecdotes "Surely You're Joking, Mr. Feynman." He said some nine years before receiving the Nobel prize, "Many scientists do believe in both science and God, the God of revelation, in a perfectly consistent way." So is it possible to be a scientist and a Christian? Yes, according to Richard Feynman, an outspoken atheist.

A good summary statement in this regard is by Alan Lightman, who has written a very well received book called "Origins: the Lives and Worlds of Modern Cosmologists." Dr. Lightman is an M.I.T. professor who has published this seminal work with the Harvard University Press. A critical paragraph of the book states:

"References to God or divine purpose continued in the scientific literature until the middle to late 1800s. It seems likely that the studied lack of religious references after this time resulted more from a change in social and professional convention among scientists rather than from any change in underlying thought. Indeed, contrary to popular myth, scientists appear to have the same range of attitudes about religious matters as does the general public."

Now someone could regard the above statement as strictly anecdotal. Many Americans like statistics better than anecdotes. So let me present the results of a poll of the members of the scientific professional society Sigma Xi. Three thousand three hundred scientists responded to the survey, so this is certainly beyond statistical uncertainty. The description in the November 7, 1988 issue of "Chemical and Engineering News" reads "Scientists are anchored in the U. S. mainstream." The article states that half of the scientists polled participate in religious activities regularly. Looking at the poll more carefully, one sees that something like 41% of Ph.D. scientists are in church on a typical Sunday. In the general American public, perhaps 42% are in church on a typical Sunday. So it is clear that whatever it is that causes people to adopt religious inclinations is unrelated to having an advanced degree in science.

Let us go a little deeper with a statement from Michael Polanyi (1891-1976), professor of chemistry and later of philosophy at the University of Manchester. His son John Polanyi won the Nobel prize in 1986. I think that it may be true that when John Polanyi's scientific accomplishments, which have been truly magnificent, have been mostly forgotten, the impact of his father's work will continue.

Michael Polanyi was a great physical chemist at the University of Manchester. About halfway through his career, he switched over to philosophy, and particularly the philosophy of science. He was equally distinguished there. His books, the most influential of which is called "Personal Knowledge," are not easy to read, but are very worthwhile. He was of Jewish physical descent, raised in Budapest, Hungary. About

the same time that he began the switch from chemistry to philosophy, he joined the Roman Catholic church. A typical Michael Polanyi statement reads:

"I shall reexamine here the suppositions underlying our belief in science and propose to show that they are more extensive than is usually thought. They will appear to coextend with the entire spiritual foundations of man, and to go to the very root of his social existence. Hence I will urge our belief in science should be regarded as a token of much wider convictions."

If you read further, you will probably come to the same conclusion that I draw. Polanyi points out that the observer is always there in the laboratory. He or she always makes conclusions. He or she is never neutral. Every scientist brings presuppositions to his or her work. A scientist, for example, never questions the basic soundness of the scientific method. This faith of the scientist arose historically from the Christian belief that God the father created a perfectly orderly universe. Now I must provide some concrete evidence for the latter conclusion.

Why Might a Scientist Become a Christian?

I will ask this question several times in the course of the present lecture. Physics Nobelist Eugene Wigner (1902-1995) once noted "the unreasonable effectiveness of mathematics" and remarked that "the miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift that we neither understand nor deserve." Interestingly, Wigner (like Polanyi) was a man of Jewish origin who found his way into nominal Christendom, in Wigner's case Protestantism. Indirectly, Wigner is hinting that the intelligibility of the universe points to a sovereign creator God. Thus mathematical physics can be an answer to the question we pose in this section. The laws of nature look just as if they have been selected as the most simple and elegant principles of intelligible change by a wise creator. Belief in the intelligibility of nature strongly suggests the existence of a cosmic mind, who can construct nature in accordance with rational laws. Dr. Keith Ward, Regius Professor at Oxford University, well stated in April 1999:

"Thus appeal to the general intelligibility of nature, its structuring in accordance with mathematical principles which can be understood by the human mind, suggests the existence of a creative mind, a mind of vast wisdom and power. Science is not likely to get started if one thinks that the universe is just a chaos of arbitrary events, or if one thinks there are many competing gods, or perhaps a god who is not concerned with elegance or rational structure. If one believes those things, one will not expect to find general rational laws, and so one will probably not look for them. It is perhaps no accident that modern science really began with the clear realization that the Christian God was a rational creator, not an arbitrary personal agent."

I need to be clear that it is not only persons with Christian sympathies who acknowledge the remarkable intelligibility of the universe. For example, Sheldon Glashow (Nobel Prize in Physics, 1979) stated in 1990:

"Many scientists are deeply religious in one way or another, but all of them have a certain rather peculiar faith - they have a faith in the underlying simplicity of nature; a belief that nature is, after all, comprehensible and that one should strive to understand it as much as we can."

However, without a belief in the sovereign God of the universe, one may project such general observations in questionable directions. For example, Glashow continues:

"Now this faith in simplicity, that there are simple rules - a few elementary particles, a few quantum rules to explain the structure of the world - is completely irrational and completely unjustifiable."

Science Developed in a Christian Environment

I like to begin with an outrageous statement that always causes reaction. This is a statement from a British scientist, Robert Clark, and it will at least make you think. Clark states in his book "Christian Belief and Science:"

"However we may interpret the fact, scientific development has only occurred in a Christian culture. The ancients had brains as good as ours. In all civilizations - Babylonia, Egypt, Greece, India, Rome, Persia, China and so on - science developed to a certain point and then stopped. It is easy to argue speculatively that, perhaps, science might have been able to develop in the absence of Christianity, but in fact, it never did. And no wonder. For the non-Christian world believed that there was something ethically wrong about science. In Greece, this conviction was enshrined in the legend of Prometheus, the fire-bearer and prototype scientist who stole fire from heaven, thus incurring the wrath of the gods."

I would prefer if Dr. Clark had said "sustained" scientific development in the first sentence quoted above. I think he went a little too far here, but his words certainly give people something to cogitate.

A frequent objection to Clark's statement is that science made significant progress in the Middle East under Islam during the Middle Ages. This is of course true, but why did these early scientific contributions fail to be "sustained?" In his important 2002 book Professor Bernard Lewis of Princeton University has addressed this critical question. Lewis's book is appropriately titled "What Went Wrong? The Clash between Islam and Modernity in the Middle East." The inability of science to continue under Islam is perhaps best illustrated by the fate of the great observatory built in Galata, in Istanbul, in 1577. This observatory gave every promise of being comparable to that of the Danish scientist Tycho Brahe (1546-1601), who revolutionized astronomy. In "What Went Wrong?" Lewis relates that the observatory at Galata was razed to the ground by an elite corps of Turkish troops, by order of the sultan, on the recommendation of the Chief Mufti (Islamic leader) of Istanbul. For the next 300 years there was no modern observatory in the Islamic world.

Let us explore the idea involved in the statements that Polanyi, Ward, and Clark made; that is, that modern science grew up in a Christian environment. I was taught in my childhood that Francis Bacon (1561-1626) discovered the scientific method. The higher critics have now gotten into the history of science and some claim that Bacon stole the scientific method from a multitude of others and just popularized it. We must leave that dilemma to the science historians to settle.

One of Francis Bacon's most frequently quoted statements is called the "Two Books" manifesto. These words of Bacon have been highly influential and the subject of a magnificent recent essay by Thomas Lessl. Francis Bacon said:

"Let no one think or maintain that a person can search too far or be too well studied in either the book of God's word or the book of God's works."

Bacon is talking about the Bible as the book of God's words and nature as the book of God's works. He is encouraging us to learn as much as possible about both. So, right here in the earliest days of the scientific method, we have a statement of the compatibility of science with the 66 books of the Hebrew Bible and New Testament. I have taken Bacon's advice personally, having read through the Bible a dozen times since I became a Christian in 1973.

Johannes Kepler (1571-1630) was a brilliant mathematician, physicist, and astronomer. Kepler posited the idea of elliptical orbits for planets and is considered the discoverer of the laws of planetary motion. He was a devout Lutheran Christian. When he was asked the question "Why do you engage in science?", Kepler answered that he desired in his scientific research "to obtain a sample test of the delight of the Divine Creator in His work and to partake of His joy. This has been re-stated in many ways by other people, to think God's thoughts after him, to know the mind of God, and so on. Kepler might be mistakenly considered a Deist based on this first statement alone. But he elsewhere clarified:

"I believe only and alone in the service of Jesus Christ. In him is all refuge and solace."

Blaise Pascal (1623-1662) was a magnificent scientist. He is the father of the mathematical theory of probability and combinatorial analysis. He provided the essential link between the mechanics of fluids and the mechanics of rigid bodies. And he is in my opinion the only physical scientist to make profound contributions to Christian thinking. Many of these thoughts are found in the little book, the "Pensees," which I was required to read as a sophomore at M.I.T. They were trying to civilize us geeks, but a few years later M.I.T. decided that it was not working, so current students are not required to take as many humanities courses.

Pascal's theology is centered on the person of Jesus Christ as Savior and based on personal experience. He stated that God makes people

"conscious of their inward wretchedness (which the Bible calls sin) and his infinite mercy, unites Himself to their inmost soul, fills it with humility and joy, with confidence and love, renders them incapable of any other end than Himself. Jesus Christ is the end of all and the center to which all tends."

Robert Boyle (1627-1691) was perhaps the first chemist. He gave the first operational definition of an element, demonstrating enormous ingenuity in constructing experiments in support of the atomistic hypothesis. Many of my freshman chemistry students remember Boyle's law. I typically return to Berkeley for a week or two every year, and every once in a while I will meet one of my former chemistry students on the campus. They typically ask "Didn't you use to be Professor Schaefer?" I ask them in return "What do you remember from my freshman chemistry course?" Occasionally they will say: "pV = nRT." Then I know that I was fabulously successful. This of course is the ideal gas law, of which Boyle's law is a critical part.

Boyle was a busy person. He wrote many books, one of which is "The Wisdom of God Manifested in the Works of Creation." He personally endowed an annual lectureship promoted to the defense of Christianity against indifferentism and atheism. He was a good friend of Richard Baxter, one of the great Puritan theologians. He was governor of the Corporation for the Spread of the Gospel of Jesus Christ in New England.

Although I disagree, a recent poll concerning the most important person in history gave that honor to Sir Isaac Newton (1642-1727). Newton was a mathematician, physicist, co-discoverer with Liebnitz of calculus, and the founder of classical physics. He was the first of the three great theoretical physicists. He also investigated many other subjects. Newton tried very hard to do chemistry, but was less than successful. He wrote more words about theology than science. Still in print is his book about the return of Jesus Christ, entitled "Observations on the Prophecy of Daniel and the Revelation of St. John." One of Newton's most frequently quoted statements is:

"This most beautiful system of the sun, planets and comets could only proceed from the counsel and dominion of an intelligent and powerful Being."

One might assume from the above statement that Newton was a deist (the system of natural religion that affirms God's existence but denies revelation). However, typical Newton statements like the following show that this is not true:

"There are more sure marks of authenticity in the Bible than in any profane history."

In fact, one may more reasonably conclude that Newton was a Biblical literalist than a Deist. Edward B. Davis ("Science and Christian Belief," pages 103-117, October 1991) writes that for Newton:

"It was not enough that an article of faith could be deduced from Scripture: 'It must be expressed in the very form of sound words in which it was delivered by the Apostles.

For men are apt to run into partings about deductions. All the old heresies lay in deductions. The true faith was in the Biblical texts.'"

George Trevelyan, the distinguished secular historian, summarized the contributions I have been discussing as follows ("English Social History," 1942):

"Robert Boyle, Isaac Newton and the early members of the Royal Society were religious men, who repudiated the skeptical doctrines of Thomas Hobbes. But they familiarized the minds of their countrymen with the idea of law in the universe and with scientific methods of inquiry to discover truth. It was believed that these methods would never lead to any conclusions inconsistent with Biblical history and miraculous religion. Newton lived and died in that faith."

Beyond the 18th Century

My very favorite among these legendary figures and probably the greatest experimental scientist of all time is Michael Faraday (1791-1867). The two hundredth birthday of Michael Faraday's birth was celebrated in 1991 at the Royal Institution (the multi-disciplinary scientific research laboratory in London, of which Faraday was the Director). There was an interesting article published in this context by my friend Sir John Meurig Thomas, who said if Michael Faraday had lived into the era of the Nobel prize, he would have been worthy of eight Nobel prizes. Faraday discovered benzene and electromagnetic induction, invented the generator, and was the main architect of the classical field theory of electromagnetism.

Let me contrast the end of Faraday's life with the end of Lev Landau's life, previously described. As Faraday lay on his death bed, a friend and well-wisher came by and said, "Sir Michael, what speculations have you now?" This friend was trying to introduce some cheer into the situation. Of course the passion of Faraday's career had consisted of making "speculations" about science and then dashing into the laboratory to either prove or disprove them. It was a reasonable thing for a friend to say in a difficult situation. Faraday took the question very seriously. He replied:

"Speculations, man, I have none! I have certainties. I thank God that I don't rest my dying head upon speculations for I know whom I have believed and am persuaded that he is able to keep that which I have committed unto him against that day."

The first time I used this statement in a public setting (nearly 20 years ago) a bright eyed and bushy-tailed young person in the front row of the audience burst out "I've heard that before, and I am delighted to know that it was Michael Faraday who first spoke those words." As gently as possible, I informed him that the words were first penned by St. Paul some 1800 years earlier to express his confidence in Jesus Christ. Michael Faraday had a firm grasp of the New Testament.

The second of the three great theoretical physicists of all time would certainly have to be James Clerk Maxwell (1831-1879). Trevor Williams ("Biographical Dictionary of Scientists," 1982) has summarized Maxwell's career this way:

"Maxwell possessed all the gifts necessary for revolutionary advances in theoretical physics: a profound grasp of physical reality, great mathematical ability, total absence of preconceived notions, a creative imagination of the highest order. He possessed also the gift to recognize the right task for this genius - the mathematical interpretation of Faraday's concept of electromagnetic field. Maxwell's successful completion of this task, resulting in the mathematical [field] equations bearing his name, constituted one of the great achievements of the human intellect."

Those who have thought deeply about the history and philosophy of science (e.g., Michael Polanyi and Thomas Kuhn) would disagree with one statement made above. If Maxwell indeed had a "total absence of preconceived notions," he would have accomplished a total absence of science.

Although Maxwell's Equations are indeed one of the great achievements of the human intellect, as a member of the M.I.T. sophomore physics class during the 1963-1964 academic year, I probably would have described them in different language at the time. However, just before our first examination in eletromagnetism, one of the members of our class had a brilliant idea. This entrepreneurial wag had 900 teeshirts printed with Maxwell's Equations embossed in large script. The entire class showed up to the first exam dressed in this unusual garb. Maxwell's Equations were plainly visible from every seat in the auditorium. Our class averaged 95% on the first E&M exam! Regrettably, the professor was distinctly unhappy. The average on his second exam, despite our awesome teeshirts, was 15%. Never mess with a professor.

On June 23, 1864 James Clerk Maxwell wrote:

"Think what God has determined to do to all those who submit themselves to his righteousness and are willing to receive his gift [the gift of eternal life in Jesus Christ]. They are to be conformed to the image of His Son, and when that is fulfilled, and God sees they are conformed to the image of Christ, there can be no more condemnation."

Maxwell and Charles Darwin were contemporaries. Many wondered what a committed Christian such as Maxwell thought of Darwin's ideas. In fact, Maxwell once was invited to attend a meeting on the Italian Riviera in February to discuss new developments in science and the Bible. If you have ever spent time in Cambridge, England, you know it is very gloomy in the wintertime. If I had been a member of the Cambridge faculty, I would have taken every opportunity to go to the Italian Riviera at this time of the year. However, Maxwell turned down the invitation, explaining in his letter of declination:

"The rate of change of scientific hypotheses is naturally much more rapid than that of Biblical interpretation. So if an interpretation is founded on such a hypothesis, it may help to keep the hypothesis above ground long after it ought to be buried and forgotten."

This is sage advice. An example of just this is the steady state theory, which was popularized by Fred Hoyle and others. It was for decades one of the two competing theories of the origin of the universe. The steady state hypothesis basically says that what you see is what was always there. It became less tenable in 1965 with the observation of the microwave background radiation by Arnold Penzias and Robert Wilson. (Much more on this in my "Big Bang" lecture.) There are not many cosmologists left who believe in the steady state hypothesis. But it is amusing to go back to about 1960, find Biblical commentaries on the book of Genesis, and see how an unfortunate few explain how the steady state hypothesis can be reconciled with the first chapter of Genesis. Any reasonable person can see that the Genesis account is describing a creation from nothing (ex nihilo), so it takes a vivid imagination to reconcile a beginning in space, time, and history with the now discredited steady state hypothesis. By the second half of the twenty-first century, should planet earth still be here, the steady state hypothesis will be dead and nearly forgotten. These commentaries will probably still be available in libraries, but few people will be able to understand them. This is an excellent example of the important point made by James Clerk Maxwell well more than a century ago.

One of my favorite cartoons was published by Sidney Harris a few years ago in "The American Scientist." Two distinguished elderly scientists are staring unhappily at an obscure equation on a blackboard. One of them delivers the punch line: "What is most depressing is the realization that everything we believe will be disproved in a few years." I hope that is not true of my students' research in quantum chemistry. I don't think it will be the case, but there is an important element of reality to this, in that science is inherently a tentative activity. As scientists we come to understandings that are always subject, at the very least, to further refinements.

Of course, not all biographers of these pioneers of modern physical science spoke positively of their Christian convictions. For example, James Crowther states in his biography of Faraday and Maxwell:

"The religious decisions of Faraday and Maxwell were inelegant, but effective evasions of social problems that distracted and destroyed the qualities of the works of many of their ablest contemporaries."

In context, what Crowther is saying is that because they were Christians, Maxwell and Faraday did not become alcoholics, womanizers, or social climbers, to enumerate the disabling sins of a number of gifted scientists of the same era.

I need to insert a little organic chemistry here, so that my colleagues on the organic side will know that I paid some attention to them. William Henry Perkin (1838-1907) was perhaps the first great synthetic organic chemist. Perkin was the discoverer of the first synthetic dye, known as Perkin's mauve or aniline purple. Prior to Perkin's discovery, the use of the color purple had been extremely expensive and often limited to persons of royal descent. He is the person for whom an important journal, the Perkin

Transactions of the Royal Society of Chemistry (London), is named. In the year 1873, at the age of 35, Perkin sold his highly profitable business and retired to private research and church missionary ventures. One of the more humorous responses to the present lecture was a suggestion from the audience a few years back that I follow William Henry Perkin's example in this particular respect.

Perkin was carrying out research on unsaturated acids three days prior to his death, brought on by the sudden onset of appendicitis and double pneumonia. The following account is given in Simon Garfield's 2001 biography of Perkin. On his deathbed, William Henry Perkin stated "The children are in Sunday School. Give them my love, and tell them always to trust Jesus." He then sang the first verse of the magisterial Isaac Watts hymn "When I Survey the Wondrous Cross." When he reached the last line, which reads "And pour contempt on all my pride," Perkin declared "Proud? Who could be proud?"

One can find the name of George Stokes (1819-1903) in any issue of the Journal of Chemical Physics, the most prestigious journal in my field. In recent issues, Coherent Anti-Stokes Raman Spectroscopy (CARS) is a subject of much scholarly investigation. Stokes was one of the great pioneers of spectroscopy, fluorescence, and the study of fluids. He held one of the most distinguished chairs in the academic world for more than fifty years, the Lucasian Professorship of Mathematics at Cambridge University. This was the position held by Sir Isaac Newton and is the chair currently occupied by Stephen Hawking, subject of the second lecture in this series. Stokes was also the president of the Royal Society of London.

Stokes wrote on a range of matters beyond chemistry and physics. Concerning the question of miracles, Stokes wrote in his book "Natural Theology," published in 1891:

"Admit the existence of God, of a personal God, and the possibility of miracles follows at once. If the laws of nature are carried out in accordance with His will, He who willed them may will their suspension. And if any difficulty should be felt as to their suspension, we are not even obliged to suppose that they have been suspended."

William Thomson (1824-1907) was later known as Lord Kelvin. Lord Kelvin was recognized as the leading physical scientist and the greatest science teacher of his time. His early papers on electromagnetism and his papers on heat provide enduring proof of his scientific genius. He was a Christian with a strong faith in God and the Bible. In a speech to University College in 1903 Kelvin stated:

"Do not be afraid of being free thinkers. If you think strongly enough, you will be forced by science to the belief in God."

In 1897, J. J. Thomson (1856-1940) identified and characterized the electron, one of the most profound discoveries in the history of science. J. J. Thomson was for many years the Cavendish Professor of Physics at Cambridge University. The old Cavendish Laboratory still sits in the middle of the beautiful Cambridge campus. So many

remarkable discoveries were made in the old Cavendish that it has essentially become a museum. A total of something like a dozen Nobel prizes resulted from research done in that laboratory. When the old Cavendish was opened by James Clerk Maxwell in 1874, he had a Latin phrase from Psalm 111 carved over the front door. Perhaps ten years ago I had my daughter Charlotte, who subsequently graduated from Stanford University in classics, translate this phrase for me. Then we walked out into the Cambridge countryside, where the shiny new Cavendish Laboratory was dedicated in 1973. Placed over the front door is the very same phrase, but this time in English: "The works of the LORD are great, sought out of all them that have pleasure therein." Cavendish Professor J. J. Thomson made this statement in "Nature" (a journal in which I have actually published):

"In the distance tower still higher [scientific] peaks which will yield to those who ascend them still wider prospects, and deepen the feeling whose truth is emphasized by every advance in science, that 'Great are the works of the Lord'." (Nature, Volume 81, page 257, 1909)

For the brilliant J. J. Thomson, the bottom line in science was that the works of the Lord are magnificent.

Those who know my research will not be surprised that this lecture must include at least one theoretical chemist. Let's make it three in this paragraph. Charles Coulson (1910-1974) was one of the three principal architects of the molecular orbital theory. I had the privilege of meeting Coulson just once, at the Canadian Theoretical Chemistry Conference in Vancouver in 1971. He probably would have received the Nobel prize, but he did not pass the usual first test. This typical first hurdle to getting the Nobel prize is to live to be 65 years old - a wonderful excuse for those of us comfortably below that threshold who have not made the trip to Stockholm. The second test, far more challenging, is to have done something very important when you were 30-40 years old. Coulson indeed did profoundly significant work when he was in his thirties, but he died at 64, thus disqualifying himself from the Nobel prize. Coulson, a professor of mathematics and theoretical chemistry at Oxford University for many years, was also a Methodist lay minister. Norman March (a good friend), successor to the renamed Coulson Chair of Theoretical Chemistry, was also a Methodist lay minister. Alas, upon the retirement of Professor March a few years ago, a suitable Methodist lay minister could not be found for the Coulson Chair at Oxford. So the university settled for an Anglican Christian, Professor Mark Child (also a friend). Charles Coulson was a spokesman for Christians in academic science and the originator of the term "god of the gaps," now widely used in philosophical circles. From the biographical memoirs (1974) of the Royal Society of London, following Charles Coulson's death, we read Coulson's own description of his conversion to faith in Jesus Christ in 1930 as a 20 year old student at Cambridge University:

"There were some ten of us and together we sought for God and together we found Him. I learned for the first time in my life that God was my friend. God became real to me, utterly real. I knew Him and I could talk with Him as I never imagined it possible

before. And these prayers were the most glorious moment of the day. Life had a purpose and that purpose coloured everything."

Coulson's experience was fairly similar to my own, 43 years later, as a young professor at Berkeley. It would be arresting if I could say that there was a thunderclap from heaven, God spoke to me in audible terms, and hence I became a Christian. However, it did not happen that way. The apostle Paul's experience was the exception rather than the rule. But I did (and still do, some 28 years later) experience the same perception that Coulson described. My life has a purpose in Jesus Christ, and that purpose colors everything.

The "Why" Question

Before we move on exclusively to contemporary scientists, let us explore some of the reasons for the obervations I have described thus far. Namely, why did sustained scientific development occur first in a Christian environment? The best answers I have seen to this question were very recently (2000) formulated by my University of Georgia chemistry colleague Dr. Wesley Allen. His (slightly modified) five answers to this question are as follows:

(1) If Christianity is true, the universe is real, not illusory. The universe is thus the product of a God whose character is immutable, at variance with pantheistic notions which place inherent distrust in sensory experience in a mercurial world.

(2) If Christianity is true, the universe, being divinely created, is of inherent value and thus worthy of study. This conclusion supplants any Zeitgeist which would view science as a mere intellectual pastime.

(3) If Christianity is true, nature itself is not divine, and thus humanity may probe it free of fear. This was an important realization in early eras dominated by superstitions about the natural environment. Worship and ultimate reverence is reserved for the Creator, not the creation, nor humans as creatures therein.

(4) If Christianity is true, mankind, formed in the image of God, can discover order in the universe by rational interpretation. That is, the codes of nature can be unveiled and read. Without such faith, science might never have developed, because it might have appeared impossible in principle.

(5) If Christianity is true, the form of nature is not inherent within nature, but rather a divine command imposed from outside nature. Thus, the details of the world must be uncovered by observation rather than by mere rational musing, because God is free to create according to His own purposes. In this way science was liberated from Aristotelian rationalism, whereby the Creator was subjected to the dictates of reason constructed by humans. Such gnosticism, which transformed speculation into dogma, undermined the open-endedness of science. To be sure, Christianity holds that God is a perfectly rational being who cannot act inconsistently with His character. But this

principle only places partial constraints on His creative activity, which science must be free to discover in all its diversity.

Contemporary Scientists

Robert Griffiths (1937-), a member of the U.S. National Academy of Sciences, is the Otto Stern Professor of Physics at Carnegie-Mellon University. He received one of the most coveted awards of the American Physical Society in 1984 for his work on statistical mechanics and thermodynamics. The magazine "Physics Today" reported that Griffiths is an evangelical Christian who is an amateur theologian and who helps teach a course at Carnegie-Mellon on Christianity and science. I find this to be particularly intriguing, since for the last five years I have taught a freshman seminar at the Univeristy of Georgia on the same subject. In the April 3, 1987 issue of "Christianity Today" Professor Griffiths made the interesting statement:

"If we need an atheist for a debate, I go to the philosophy department. The physics department isn't much use."

At the University of California at Berkeley, where I was a professor for 18 years, we had 50 chemistry professors. But for many years there was only one who was willing to publicly identify himself as an atheist, my good friend Robert Harris, with whom I still have occasional discussions about spiritual things, usually during my annual summer week back on the Berkeley campus. After one such discussion perhaps 20 years ago, Bob told me he might have to rethink his position and become an agnostic. I thought to myself "OK, Bob, one step at a time." But Bob came back to me a week later, firmly reinstalled in the atheist camp. A more recent addition to the Berkeley chemistry faculty is a second open atheist, Richard Saykally. Rich is also a close friend, soundly disproving the notion that disagreements about ultimate questions necessarily lead to personal rancor.

For many years, Richard Bube (1927-) was the chairman of the Department of Materials Science at Stanford University. No less than 56 Stanford graduate students have received their Ph.D. degrees under Professor Bube's direction. Bube has carried out foundational research in solid state physics concerning semiconductors, the photoelectronic properties of materials, photovoltaic devices (solar cells), and amorphous materials. He seconds Robert Griffiths' above statement, noting

"There are proportionately as many atheistic truck drivers as atheistic scientists."

Richard Bube has long been a spokesmen for evangelical Christians in academic life, serving for many years as editor of the journal "Perspectives on Science and the Christian Faith," published by the American Scientific Affiliation, of which I am a Fellow. Bube currently teaches a second year undergraduate course at Stanford entitled "Issues in Science and Christianity."

Another member of the U.S. National Academy of Sciences is John Suppe, noted professor of geology at Princeton University. John is an outstanding scholar in the area of plate tectonics, the deformation of the earth's crust. Vaguely aware of his own spiritual needs, he began attending services in the Princeton chapel, then reading the Bible and other Christian books. He eventually committed himself to Christ and, remarkably, had his first real experience of Christian fellowship in Taiwan, where he was on a prestigious Guggenheim Fellowship. I have spoken before the Christian faculty forum at the National Taiwan University in Taipei, so I know personally that they are a good group.

Suppe makes some interesting comments concerning the evolution controversies:

"Some non-scientist Christians, when they meet a scientist, feel called on to debate evolution. That is definitely the wrong thing to do. If you know scientists and the kinds of problems they have in their lives: pride, selfish ambition, jealousy; that's exactly the kind of thing Jesus talked about, and which he came to resolve (by His death on the cross). Science is full of people with very strong egos who get into conflicts with each other. .....The gospel is the same for scientists as for anyone. Evolution is basically a red herring. If scientists are looking for meaning in their lives, it won't be found in evolution."

Although I will have more to say about evolution, and especially the origin of life, in a later lecture, John Suppe certainly provides a good practical starting point.

My candidate for scientist of the twentieth century is Charles Townes (1915-), who received the 1964 Nobel Prize in Physics for his discovery of the laser. However, I must confess to some possible bias, since Professor Townes is the only plausible candidate for scientist of the century that I know personally. But the laser is a discovery that has significantly impacted the life of every person who reads these words. Dr. Townes almost received a second Nobel prize for his observation of the first interstellar molecule. The study of interstellar molecules has subsequently become an major part of astrophysics, affecting even my own research. I will have more to say about this in the "Big Bang" lecture. Charles Townes was the Provost at M.I.T. when I was an undergraduate, and later a colleague (but in the physics department) during my 18 years on the faculty at Berkeley.

At Berkeley every Ph.D. oral examination requires four faculty members from the candidate's own department and a fifth committe member from an outside department. In chemical physics, which is actually a part of the chemistry department at Berkeley, the "outside" committee member is almost inevitably a physics faculty member. This puts a significant strain on some of the physics faculty, since only a few of them are sufficienty knowledgeable about chemistry to serve on such committees, of which about 30 must be constituted each year. So it was not unusual for this particular subset of the physics faculty to come up with highly original reasons why they were unavailable for such two hour ordeals. But Charlie Townes was never such a one. He always served the chemistry department cheerfully, although his duties in Washington and elsewhere were legiaon. And his demeanor on these committees was always gentlemanly to a

tee. His questions to the chemistry Ph.D. students were almost inevitably thoughtful, and designed to bring out the very best in a quaking student.

Charles has written an autobiography entitled "Making Waves," a pun referring to the wavelike phenomena that scientifically describe lasers. The book was published in 1995 by the American Institute of Physics, and I recommend it. Charlie makes reference to his church involvement and then provides the statement:

"You may well ask, 'Just where does God come into this?' Perhaps my account may give you some answer, but to me that's almost a pointless question. If you believe in God at all, there is no particular 'where'. He's always there - everywhere. He's involved in all of these things. To me, God is personal yet omnipresent - a great source of strength, Who has made an enormous difference to me."

Arthur Schawlow (1921-2000) won the Nobel Prize in Physics in 1981 for his work in laser spectroscopy. Artie Schawlow served until his recent death as a professor at Stanford and was a truly beloved figure in the physics community. He did not heistate to identify himself as a Protestant Christian. And he makes this unusual statement, which I suspect might only be made by a scientist:

"We are fortunate to have the Bible, and especially the New Testament, which tells so much about God in widely accessible human terms."

I know that Arthur Schawlow believed that his experimental studies of molecular spectroscopy were also telling him something about God's creative powers. The contrast with the New Testment accounts of the life of Jesus was that Schawlow did not think that his work was providing information about God in "widely accessible human terms."

John Polkinghorne (1930-) was the chaired Professor of Mathematical Physics at Cambridge University from 1968 to 1979. This is the "other" chair of theoretical physics at Cambridge, in addition to that held by Stephen Hawking. In 1979 Polkinghorne made an abrupt career switch, enrolling in theological studies before becoming an Anglican priest. Then in 1986, Polkinghorne returned to Cambridge, first as Dean of Trinity Hall and later becoming President of Queen's College. Queen's College sits just next to St. Catherine's College, where I stay in Cambridge during my frequent visits to my longtime scientific collaborator and close friend, theoretical chemistry Professor Nicholas Handy, also an Anglican. Perhaps needless to say, John Polkinghorne has been outspoken about spiritual matters:

"I take God very seriously indeed. I am a Christian believer, and I believe that God exists and has made Himself known in Jesus Christ."

My lecture on cosmology follows later, but I would like to make one particular point here as it relates to biology, and to a more general question. The world's greatest observational cosmologist is Allan Sandage (1926-), an astronomer at the Carnegie

Institution in Pasadena, California. Sandage was called the "Grand Old Man of Cosmology" by the "New York Times" when he won the highly lucrative 1991 Crafoord Prize, given by the Royal Swedish Academy of Sciences. This prize is given to a cosmologist every sixth year and is viewed by the Swedish Academy as equivalent to the Nobel prize. Allan Sandage was born into a Jewish family and committed his life to Jesus Christ at the age of 50. In the Alan Lightman book noted above, Dr. Sandage was asked the old question "Can a person be a scientist and also be a Christian?" Sandage's affirmative response is expected, but he provides a surprising focus:

"The world is too complicated in all its parts and interconnections to be due to chance alone. I am convinced that the existence of life with all its order in each of its organisms is simply too well put together."

Sandage is the person responsible for the best current scientific estimate of the age of the universe, perhaps 13 billion years. Yet when this brilliant astrophysicist is asked to explain how one can be a scientist and a Christian, he turns not to cosmology but biology. Which brings me full circle to the question I addressed earlier from the perspective of mathematical physics and the intelligibility of the universe: Why might a scientist become a Christian? The answer from biology is that the extraordinary complexity and high information content of even the simplest living thing (the simplest self-replicating biochemical system) points to a sovereign creator God.

As mentioned earlier, a typically important ingredient to receiving the Nobel Prize in Chemistry is the attainment of age 65. For example, my good friend John Pople, a serious Methodist Christian, received the Prize in quantum chemistry at the age of 73 in 1988. He shared the prize with Walter Kohn, who was 75 at the time. However, the Physics Nobel is often given to much younger individuals. William Phillips (1949-) received the Nobel Prize in Physics at the age of 48 for the development of methods to cool and trap atoms with laser light. On the announcement date, October 15, 1997, Phillips was participating in a conference on high-powered telescopes in Long Beach, California. At the mandatory press conference William Phillips spoke the words:

"God has given us an incredibly fascinating world to live in and explore."

Phillips formed and sings in the gospel choir of the Fairhaven United Methodist Church, a multi-racial congregation of about 300 in Gaithersburg, Maryland. He also teaches Sunday School and leads Bible studies. If you took the time to delve further into the October 1997 media reports, you could find out that on Saturday afternoons, William Phillips and his wife often drive into central Washington, D.C. to pick up a blind, 87 year old African-American lady to take her grocery shopping and then to dinner.

Allow me just once more to ask the critical question "Why might a scientist become a Christian?" My third answer is the remarkable fine tuning of the universe. The formidable anthropic constraints will be treated in more detail in the "Big Bang" lecture, but let me draw a picture by citing three persons with no obvious theistic inclinations. Paul Davies, an excellent popularizer of science, states:

"The present arrangement of matter indicates a very special choice of initial conditions."

Now, if language means anything, a special choice implies that someone or some thing is doing the choosing. Stephen Hawking elaborates:

"In fact, if one considers the possible constants and laws that could have emerged, the odds against a universe that has produced life like ours are immense."

And the always quotable Fred Hoyle adds:

"A common sense interpretation of the facts suggests that a superintellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature."

My own view is that all three of these skeptics, in their own unique ways, are unintentionally supporting the position put forth by St. Paul more than 1900 years earlier:

"For since the creation of the world God's invisible qualities - His eternal power and divine nature - have been clearly seen, being understood from what has been made." Romans 1:20.

3. Two Common Questions

Prior to my concluding remarks, I would like to respond to two questions that are freqently raised following this lecture. The first is "Given the evidence you present, why do so many persist in the belief that it is not possible to be a scientist and a Christian?" Although I am about as far from being a conspiracy theorist as possible, I conclude that part of the problem is indeed misrepresentation. The respected British science historian Colin Russell has described T. H. Huxley's important role in these developments in his scholarly account in the April 1989 issue of "Science and Christian Belief," the quarterly publication of the Victoria Institute, of which I have been a member for the past fifteen years. Here, rather, I would like to focus on a famous book published in 1896, entitled "The History of the Warfare of Science with Theology." Of course, given the origins of modern science, such a title sounds rather silly. The author of this polemic was Andrew Dickson White, the first President of Cornell University, the first North American university founded on purely secular terms. The most famous passage in White's book reads:

"[John] Calvin took the lead in his "Commentary on Genesis," by condemning all who asserted that the earth is not the center of the universe. He clinched the matter by the usual reference to the first verse of the 93rd Psalm and asked, 'Who will venture to place the authority of Copernicus above that of the Holy Spirit?'"

Perhaps needless to say, this is not making John Calvin look good. Nor was that Andrew Dickson White's intention. However, the truth of this matter has recently been brought forth by Dr. Alister McGrath, the Bampton Lecturer at Oxford University. In his definitive 1990 biography of Calvin, McGrath writes:

"This assertion (by White) is slavishly repeated by virtually every writer on the theme 'religion and science,' such as Bertrand Russell in his 'History of Western Philosophy.' Yet it may be stated categorically that Calvin wrote no such words (in his Genesis commentary) and expressed no such sentiments in any of his known writings. The assertion that he did is to be found, characteristically unsubstantiated, in the writings of the nineteenth century Anglican dean of Canterbury, Frederick William Farrar (1831-1903)."

It would be fair to ask what Calvin really thought of Copernicus' heliocentric theory of the solar system. The honest answer is that we do not know. Calvin was probably not familar with the work of Copernicus, who was hardly a household word in France or Switzerland during the former's lifetime. But in his preface to his friend Pierre Olivetan's translation (1534) of the New Testament into French, Calvin wrote:

"The whole point of Scripture is to bring us to a knowledge of Jesus Christ. And having come to know Him (with all that this implies), we should come to a halt and not expect to learn more."

The second frequently asked question following this lecture is "OK, OK, but how does it change your science?" Having first heard this question at Stanford University 15 years ago, I have had plenty of time to develop a good answer. But I must confess that I cannot qualitatively improve on the answer given by the brilliant Notre Dame historian George Marsden in his 1997 Oxford University Press book "The Outrageous Idea of Christian Scholarship." My answer modifies Marsden's only slightly. In science, Christian faith can have a significant bearing on scholarship in at least four ways:

(1) One's Christian faith may be a factor in motivating a scientist to do his or her work well. This is not to deny that some atheist or agnostic scholars may be just as motivated to work with just as much integrity. For any particular scholar, however, Christianity may be an important motivator.

(2) One's Christian faith may help determine the applications one sees for his or her scholarship. One may carry out research in anything from materials science to molecular biology with the hope that it may contribute to the well-being of others. Again, the fact that some atheists are also altruistic does not negate the Christian contribution to altruism.

(3) Such motives may help shape a sub-field, specialty, or the questions a person asks about his or her research. For example, I readily confess that my scientific interest in interstellar molecules was initially inspired by the oft-repeated claims that this field will

ultimately explain the origin of life. Ultimate questions tend to be of special interest to Christians.

(4) When on occasion the scientist is asked to reflect on the wider implications of his or her scholarship, faith may have an important bearing on how that person sees the field, or its assumptions, fitting into a larger framework of meaning.

4. Concluding Remarks

My collection of scientists with Christian commitments is far from exhaustive. The publication of this lecture will surely bring me correspondence from near and far with excellent new examples of the genre. Should a second edition be forthcoming, I will be happy to attempt to incorporate new material. Please do send cards and letters. But I should mention now a few others not included above. Among chemists, Professors Andrew Bocarsly (Princeton University) and James Tour (Rice University) have given Christian testimonies that have touched my heart and mind in a special way. Both Andy and Jim were born into Jewish families and gave their lives to Jesus Christ during their undergraduate years. Bocarsly is an inorganic photochemist and Tour a synthetic organic chemist turned materials scientist. Jim Tour's work on fullerenes, bucky tubes, and more generally nanochemistry is definitely on track for a trip to Stockholm some December, perhaps a decade from now.

The present discussion has focused on physics and chemistry for the obvious reason that I am a chemical physicist. This is my professional life. I suspect that it would be possible to make a similar case for the biological sciences. For example, Biochemistry Professor David Cole was the steadfast leader of the Christian faculty organization during my years on the Berkeley campus. Francis Collins is one of the most outstanding research biologists of our generation. While a professor at the University of Michigan, Collins discovered the cystic fibrosis gene. For the past five years, Francis Collins has been Director of the now successful National Institutes of Health (NIH) Human Genome Project, the largest scientific project ever undertaken. His paper "The Human Genome Project: Tool of Atheistic Reductionism or Embodiment of the Christian Mandate to Heal?" appeared in 1999 in the journal "Science and Christian Belief" (volume 11, number 2). Collins introduces his paper in this way:

"Let me begin by saying a brief word about my own spiritual path. I did not come from a strongly Christian home. I was raised in a home where faith was not considered particularly relevant, sent to church to learn music, but instructed that it would be best to avoid the theology. I followed those instructions well and went off to college with only the dimmest idea of what saving faith in Jesus Christ was all about. What little glimmers of faith I might have possessed were quickly destroyed by the penetrating questions of my freshman dorm colleagues who, as one will do at that phase in life, took great delight in destroying any remnants of superstition, which is what they considered faith to be. I became quite an obnoxious atheist with whom you would not have enjoyed having lunch. I too felt it was part of my mission to point out that all that really mattered could be discerned by science, and everything else was irrelevant.

Fortunately, through the guidance of some very patient people, who tolerated a lot of insolent questions, I was led to read C. S. Lewis and then the Bible, and so was led to understand many of the concepts that had completely eluded me before, and I gave my life to Christ 20 years ago."

I hope that this lecture has given you a flavor of the history of science. Those of you who have taken a freshman chemistry or physics course will surely recognize many of the names of the great scientists described here. In fact, the reason this first lecture in the series took its general shape was to present mini-sketches of the spiritual lives of scientists with whom my Berkeley freshman chemistry students would be familiar. There is a tremendous tradition, past and present, of distinguished scientist Christians. It gives me great joy to be a small part of that continuing tradition. And perhaps I have given you sufficient evidence that you will never again believe that it is difficult to be a scientist and a Christian. Finally, following the example of Oxford Professor Charles Coulson in his public lectures on science and the Christian faith, I encourage you to consider the advice of Psalm 34: "Taste and see that the Lord is good."

Appendix A. About the Author

Henry F. Schaefer III was born in Grand Rapids, Michigan in 1944. He received his B.S. degree in chemical physics from the Massachusetts Institute of Technology (1966) and Ph.D. degree in chemical physics from Stanford University (1969). For 18 years (1969-1987) he served as a professor of chemistry at the University of California, Berkeley. During the 1979-1980 academic year he was also Wilfred T. Doherty Professor of Chemistry and inaugural Director of the Institute for Theoretical Chemistry at the University of Texas, Austin. Since 1987 Dr. Schaefer has been Graham Perdue Professor of Chemistry and Director of the Center for Computational Quantum Chemistry at the University of Georgia. His other academic appointments include Professeur d'Echange at the University of Paris (1977), Gastprofessur at the Eidgenossische Technische Hochshule (ETH), Zurich (1994, 1995, 1997, 2000, 2002), and David P. Craig Visiting Professor at the Australian National University (1999). He is the author of more than 950 scientific publications, the majority appearing in the Journal of Chemical Physics or the Journal of the American Chemical Society.

Critical to Professor Schaefer's scientific success has been a brilliant array of students and coworkers; including 42 undergraduate researchers who have published papers, 64 successful Ph.D. students, 40 postdoctoral researchers, and 44 visiting professors who have spent substantial time in the Schaefer group. A number of his students have gone on to positions of distinction in industry (AT&T, American Cyanamid, Avaya, Chemical Abstracts, Dow Chemical, GAUSSIAN, Henkel, Hughes Aircraft, IBM, Mobil Research, Molecular Simulations, Monsanto, Proctor & Gamble, Q-CHEM, Ricoh, Schroedinger, and Sugen). Four of his graduated Ph.D.'s have successfully started their own companies. Several have gone on to successful careers in government laboratories, including the Joint Institute for Laboratory Astrophysics (JILA), Lawrence Livermore National Laboratory, NASA Ames, National Cancer Institute, National Center for Disease Control, National Institutes of Health (Bethesda), Naval Research Laboratory, Pacific Northwest National Laboratory, and Sandia National Laboratories. Charles Blahous went from his Ph.D. studies with Dr. Schaefer to the position of American Physical Society Congressional Scientist Fellow, and eventually to positions of significant importance in the U.S. political system (e.g., chief of staff for Senator Alan Simpson of Wyoming). Many of his former students have accepted professorships in universities, including the University of Alabama at Birmingham, Georgia Tech, University of Georgia, University of Giessen (Germany), University of Girona (Spain), University of Guelph (Ontario), University of Illinois-Chicago, University of Illinois-Urbana, Johns Hopkins University, University of Kentucky, University of Manchester (England), University Of Marburg (Germany), University of Mississippi, National Tsing Hua University (Taiwan), University of North Dakota, Osaka University (Japan), Pohang Institute of Science and Technology (Korea), Portland State University, Pennsylvania State University, Rice University, Rikkyo University (Tokyo), Stanford University, University of Stirling (Scotland), University of Stockholm (Sweden), University of Tasmania (Australia), Texas A&M University, the University of Texas at Arlington, and Virginia Tech.

Dr. Schaefer has been invited to present plenary lectures at more than 160 national or international scientific conferences. He has delivered endowed or named lectures or lecture series at more than thirty major universities, including the 1998 Kenneth S. Pitzer Memorial Lecture at Berkeley and the 2001 Israel Pollak Distinguished Lectures at the Technion - Israel Institute of Technology, Haifa. He is the recipient of eight honorary degrees. He is the Editor-in-Chief of the London-based journal Molecular Physics and President of the World Association of Theoretically Oriented Chemists. His service to the chemical community includes the chairmanship of the American Chemical Society's Subdivision of Theoretical Chemistry (1982) and Division of Physical Chemistry (1992). His major awards include the American Chemical Society Award in Pure Chemistry (1979, "for the development of computational quantum chemistry into a reliable quantitative field of chemistry and for prolific exemplary calculations of broad chemical interest"), the American Chemical Society Leo Hendrik Baekeland Award (1983, "for his contributions to computational quantum chemistry and for outstanding applications of this technique to a wide range of chemical problems"), the Schroedinger Medal (1990), and the Centenary Medal of the Royal Society of Chemistry (London, 1992, as "the first theoretical chemist successfully to challenge the accepted conclusions of a distinguished experimental group for a polyatomic molecule, namely methylene"). He will receive the 2003 American Chemical Society Award in Theoretical Chemistry, the citation being "For his development of novel and powerful computational methods of electronic structure theory, and their innovative use to solve a host of important chemical problems." During the comprehensive period of 1981 - 1997 Dr. Schaefer was the sixth most highly cited chemist in the world; out of a total of 628,000 chemists whose research was cited. The Science Citation Index reports that by December 31, 1999, his research had been cited more than 30,000 times. The U.S. News and World Report cover story of December 23, 1991 speculated that Professor Schaefer is a "five-time nominee for the Nobel Prize". His research involves the use of state-of-the-art computational hardware and theoretical methods to solve important problems in molecular quantum mechanics.

Professor Schaefer is also well known as a student of the relationship between science and religion. One or more of the lectures in his popular lecture series on this important topic have been presented at most major universities in North America, including Harvard, Stanford, Berkeley, Yale, Princeton, and the Universities of Alberta and Toronto. Dr. Schaefer has also presented these lectures in many universities abroad, including those in Ankara, Bangalore, Beijing, Bern, Bratislava, Budapest, Calcutta, Canberra, Cape Town, Christchurch, Cluj-Napoca, Delhi, Durban, Hong Kong, Hyderabad, Istanbul, Lausanne, London, Madras, Mumbai (Bombay), Paris, Prague, Sarajevo, Shanghai, Singapore, Sofia, St. Petersburg, Sydney, Szeged, Taipei, Tokyo, Zagreb, and Zurich. Five of these lectures have been transformed into essays, and these may be viewed on the worldwide web at leaderu.com/offices/schaefer. The lecture "The Big Bang, Stephen Hawking, and God" has been one of the most popular articles on the web for the past five years. On April 24, 2002 Dr. Schaefer received the first Erick Bogseth Nilson Award, given to an outstanding university professor in North America, by the organization Christian Leadership. A brief spiritual biography (through 1991, written by Dr. David Fisher) of Professor Schaefer may be found on pages 323 -

326 of the book "More Than Conquerors," edited by John Woodbridge (Moody Press, Chicago, 1992).

Appendix B: About the Lecture Series

New College Lectures

In 1986 the College set up a Trust to conduct an annual series of public lectures in the College. An invited lecturer is asked to take up some aspect of contemporary society, and to comment on it from the standpoint of their Christian faith and professional experience.

Lecturers have come from Australia and overseas and have brought a Christian perspective to bear on a number of issues as diverse as economics, the nature of truth, the Olympics and the Australian Constitution, just to name a few.

The lectures are free and open to members of the general public, and will be attended by University Faculty Staff, College Alumni, and present College students.

Most previous lectures have been published, and may be ordered direct from New College, or from the relevant publisher. For additional information contact the College or visit the website at www.newcollege.unsw.edu.au

Year	Title	Lecturer
1987	Mind Fields	Malcolm Jeeves
1988	Can These Bones Live?	Veronica Brady
1989	Constancy and Change	Keith Mason
1990	After Christendom?	Stanley Hauerwas
1991	History	Geoffery Bolton
1992	Environment	Peter Newman
1993	Beyond Self Interest	Robin Gill
1993	Religion and Current Science	John Polkinghorne
1994	Economics	Geoffery Brennan
1995	Beyond Science	John Polkinghorne
1996	Killing The Black Dog	Les Murray
1997	Men and Women- Constructed or Created?	Dr Elaine Storkey
1998	What is Truth?	Dr Peter Vardy
1999	If Christ Came to the Olympics	Dr William Baker
2000	Writing in Rights	Prof. Hilary Charlesworth
2001	Media Mania	Hugh McKay
2002	The Rise of Global Capitalism	Prof Craig Gay
2003	Living by the Sword: The ethics of armed intervention	Bishop Tom Frame
2004	Science & Christianity: Conflict or coherence?	Prof Henry F. Schaefer

Why are we interested in the views that ten scientists had about God? The answer is that, unintentionally or not, these scientists had a greater impact on theology than most theologians. Their work conflicted with the viewpoints of religious conservatives, but it's less clear whether their discoveries really supported atheism or actually provided evidence for the existence of a supreme intelligence.Â Hubble probably had a greater impact on mankind's viewpoints about a supreme being than any other scientist, but he scrupulously avoided giving any hint of his personal ideas about a supreme intelligence. Most of these men were scientists first and foremost, and oftentimes, they gave little thought to anything that might interfere with their work, including theology.