SCIENCE IN THE REALM OF THE SPIRIT

BY

RICHARD L. LEWIS

v. 11

Respectfully
dedicated
to the

True Parents

What is the destiny of science? Until now, scientific research has not embraced the internal world of cause, but only the external world of result; not the world of essence, but only the world of phenomena. Today science is entering a higher dimension; it is no longer concerned exclusively with the external world of result and phenomena, but has begun to examine the internal world of cause and essence as well.

DIVINE PRINCIPLE (5th ed, 1977). p. 18

Preface

This is the ninth draft of my science writings to be distributed in response to some mild interest. It is the combined draft of two works-in-progress:

The first section, with the working title *Science in the Realm of the Spirit*, is composed of columns that were written for the *Unification News* over the last ten years. They are not in publication order, rather I have tried to put them in some sort of logical sequence. They do not explore any topic exhaustively as they were written for a very general audience and the attempt was made to keep them non-technical while retaining the outline of the scientific argument.

The second section are the first eight (draft) chapters from my book with the working tile, *Formal Science*. While more technical and intended for a scientific audience, I have attempted to avoid jargon as the intent is to discuss concepts shared by physicists, chemists, biologists and evolutionist who have their own specialized language. Depending on specialty, some sections will seem overly simplified while others will seem obscure. Since this was written later than many of the columns, any disagreement represents a development in my thinking.

The perspective I am attempting to explore in my writing is the "Abel" viewpoint promoted by science that is to emerge in these times of transition. I would appreciate any constructive comments on the ideas presented here and any suggestions for improvements.

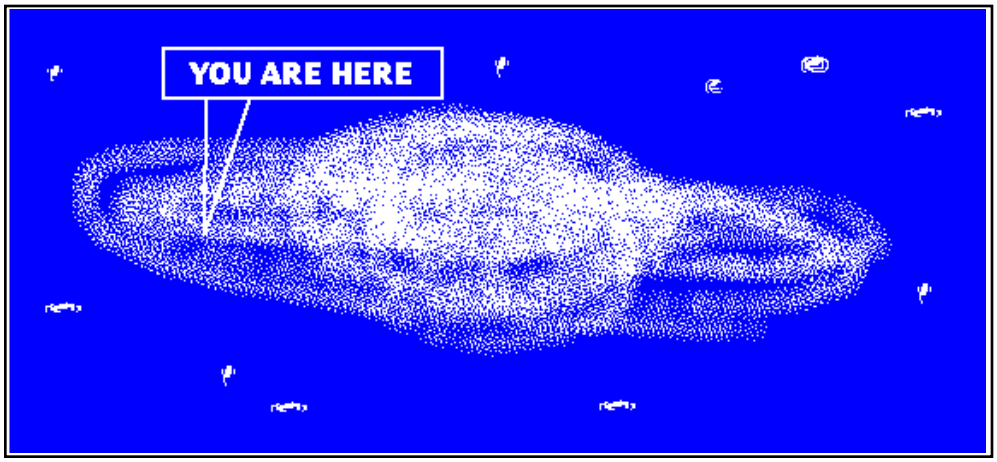
Richard L. Lewis

March 28, 2000
4 West 43rd Street
New York NY 10036
Fax: 212 768-0791
e-mail: RICHARDLLL.@AOL.COM

1. YOU WERE MEANT FOR ME, THE NUCLEAR FORCE TELLS ME SO

If, like myself, you are a parent then I am sure you have experienced the delights of reaction. The request to "Eat your cereal" draws out the determination never to touch a single flake again. The comment, "Time for sleep now," becomes the spark for another hour of 'bouncy, bouncy, fun fun fun fun fun.' Sometimes science, the practitioners of which are supposed to be aloof and above that sort of thing, give the impression of a similar, if more subtle, reaction lurking within.

Such is particularly noticeable in response to religious ideas. All religions give man a preeminent role in the universe, some even going so far as to insist that the sole purpose of the whole caboodle is to be the home (or perhaps 'school' is more appropriate) for human beings. In the mediaeval period when religion brooked no opposition, this view was universal.



I think it must be the reaction to this imposition that stimulates a similar train of thought in so many of the commentaries I have read dealing with the scientific view of the universe. That thought runs something like this: "Religion used to put human beings at the center of the universe, but science has now revealed that we are actually an insignificant speck on an unremarkable planet circling an commonplace G-type star somewhere towards the periphery of the Milky way galaxy which is remarkably similar to billions of other galaxies scattered in the unimaginable immenseness of space."

"How the mighty are fallen," they seem to sigh. "Me. Oh. My. How thoroughly trivial, how unimaginably unimportant we all are and how ridiculous was our assumption that there was any significance to human life."

This view has been cleverly summarized in that T shirt with the "You are here" sign pointing deep into the Milky Way. (Almost as clever as my favorite, "Beam me up Scotty, there's no intelligent life down here.")

This type of thinking has quite a strong influence in the scientific community, but evidence is accumulating that there might be other ways of looking at the universe that are not so at odds with the religious view that the purpose of the universe involves human beings (or at least life in general).

The Anthropic Principle

This accumulation of evidence has been spearheaded by the study of the 'Anthropic Principle.' In one of those ironic twists of history, the developers of this principle were trying to avoid people regaining any special place in the universal scheme of things.

In a fascinating overview of this subject (The Symbiotic Universe, William Morrow & Co.), George Greenstein, professor of astronomy at Amherst College, states, "The only things that can be known are those compatible with the existence of the knowers. This is the Anthropic Principle in its purest form." And, "The Anthropic Principle is the statement that if some feature of the natural world is required for our existence, then it must indeed be the case. Such a statement cannot possibly be doubted. It is logically true: true as only a tautology can be."

The circular reasoning (a simpler way of saying tautology) is that we find the universe the way it is because, if it were any different, we wouldn't be around to find it. Why would a bunch of people go to all the trouble of developing such a rather unscientific sort of principle?

The stimulus to the development of the Anthropic Principle is that the study of our universe has revealed a remarkable set of coincidences that make it eminently suitable for life. These coincidences, moreover, are suitable in such unlikely ways that one might be led to start thinking that there was some creative intelligence behind them. As this is thought to be quite a 'No No' in certain circles, you can see why it is important that these coincidences be 'explained' away by a suitable principle.

The Physical Sciences

The truly fascinating aspect of all this fuss is that it is taking place in physics, that hardest of the sciences. By 'hard,' I don't mean difficult (though memories of trying to calculate the movement of a brick sliding down an inclined plane may lead you to think otherwise), I mean mathematical. To a scientist the hardness (implying reliability, like solid marble floors and steel reinforced bridges) and softness (unreliable, like sinking in jello) of a

science is an indication of how much of it (or how little of it) can be expressed in rigorous, firm, reliable mathematical equations.

Thus the hierarchy of science: Mathematics is adamantine, Physics is super hard, Chemistry is hard, Biochemistry is firm, Biology is somewhat wobbly, Economics a liquid and Psychology a tenuous gas.

In the bygone youth of modern science it was biology that provided the believer with evidence of God's handiwork. But, as Stephen Jay Gould explains with satisfaction in his book, *Ever Since Darwin*:

"In 1802, Archdeacon Paley set out to glorify God by illustrating the exquisite adaptation of organisms to their appointed roles. The mechanical perfection of the vertebrate eye inspired a rapturous discourse on divine benevolence; the uncanny similarity of certain insects to pieces of dung also excited his admiration, for God must protect all his creatures, great and small. Evolutionary theory eventually unraveled the archdeacon's grand designs, but threads of his natural theology survive."

Survive as threads and tatters, because all the 'miracles' of life uncovered by biology can be explained away by the basic tautology of Darwinism: The survival of the survivors.

It is the discovery of the coincidences already alluded to that has prompted the development of a similar, irrefutable tautology—the existence of the existers—the in the previously hallowed halls of hard, reliable physics.

By now, I hope, you are dying to know just what these coincidences are. Just in case you do not have Dr. Greenstein's book handy, I will summarize the appendix, a list of some of these coincidences uncovered by physics. These need to be 'explained' by the Anthropic Principle because there are no other explanations currently available.

The Coincidences

These are a few of the aspects of our universe that make it eminently suitable for life:

1. There are just three dimensions to space (scientist can easily imagine more or less). It takes three, no more, no less, to allow life to flourish. Two dimensions would not allow networks (such as a nervous system or blood flow) to develop. Four dimensions or more, on the other hand, will not allow a planet to take up a stable orbit about a sun, so a planet will either fly outwards and freeze in the depths of interstellar space or fly inwards and fry in the solar inferno.

2. Most physical laws are symmetrical in regards to matter and antimatter (an unusual form of matter that nowadays exists only in minute quantities in high-energy physics laboratories and temporally during natural high-energy processes such as cosmic rays striking the atmosphere.) Matter and antimatter quickly annihilate each other and turn into pure energy. The expected symmetry of natural law predicts that the Big Bang creation of the universe should have generated equal amounts of matter and antimatter which would have mutually annihilated leaving a bright, but boring, universe consisting solely of light with no matter whatsoever—a prediction that is patently false. It appears that all the material in this universe is the result of a totally unexpected slight preference by the 'weak' nuclear force for the left hand side rather than the right. During the Big Bang the consequence of this left-handedness was that slightly more matter was created than antimatter so that a little—just a fraction of a percent—was left over after the mutual annihilation happened. All the matter in the universe today is that 'little left over.'

4. On the other hand, too much matter would be equally disastrous. The universe is actually remarkably empty and there are vast distances between the stars. If this were not so, planets in stable orbits about stars, the only possible home for life, would be impossible as they would be constantly disturbed by close encounters with nearby stars.

3. The Big Bang creation of the universe was precisely tuned in three ways. It was precisely at a calculated quantity called the critical density to an accuracy of billions of decimal places. Without this, the universe would have winked out of existence a few moments after it winked in. The Big Bang was also perfectly smooth and perfectly uniform in temperature. If it had not been, there would have been no stars just monster black holes wandering through empty space.

5. The charges on the electron and proton are exactly equal to each other, at least to the limits of our ability to measure it. Without this precise matching, objects larger than small molecules would be impossible, they would rip themselves apart through electrical imbalance.

6. The creation of the universe produced the simplest atoms, hydrogen and helium. It has been known for some time that heavier elements needed for life (carbon, oxygen etc.) can only be created in the depths of giant red stars. How? was the question, as there were two seemingly impossible steps between atomic nuclei that needed to occur. Eventually it was found that this synthesis occurs by virtue of two obscure resonances between nuclei, resonances as unexpected as finding vibrations in common between "a car, a bicycle and a truck."

7. The neutron outweighs the proton by a fraction of a percent. If it did not, stars like our Sun could only shine for about 100 years instead of the billions-year lifetime it now enjoys.

8. The balance of the four fundamental forces (gravity, electromagnetism and the two nuclear forces) is precisely such that stars have a surface temperature that emits light with energy equivalent to that involved in chemical reactions. It is this match that allows life to develop photosynthesis, the chemical trapping of energy from the Sun. A slight shift in the balance of forces would result in light with far too little or far too much energy to be used in this way.

9. The 'strong' nuclear force (the one that holds the atomic nucleus together, unlike the 'weak' which is responsible for radioactivity, its breaking apart) is just precisely right for a life-supporting environment. This force is barely strong enough to hold a deuteron (one proton and one neutron) together and the creation of a deuteron is an essential step in the nuclear burning of hydrogen into helium, the source of the sun's energy (and the hydrogen bomb, for that matter). If the force were slightly stronger, however, the generation of energy in the sun (and all stars) "would involve a fuel so ferociously reactive as to be violently unstable." No stars, no life.

Universal Necessity

These are just some of the more striking examples of how well crafted our universe is to become a home to life. It is important to realize that if all these criteria had not been met, it would not be just the planet Earth that was inhospitable to our form of life, it means that the entire immensity of the universe would be completely inhospitable to any kind of life whatsoever.

Thus the Anthropic Principle, which says in its quaint way that if all these criteria were not met then there could be no one around to notice the different state of affairs.

Which is really no explanation at all. But it's the best some of them have got.

Others, however, have chanced upon these scientific surprises and, with a twinkle in their eye (I didn't get to mention the anomalous properties of water, did I), hummed that familiar love song, "You were meant for me ....."

2. SCIENCE AS ANTI-RELIGION

How many people have lost faith in God because they thought that science has disproved, or has made untenable, their religious beliefs. I was one—I lost my faith in Catholicism because of the science I was learning in school. I went on to become a research biochemist with a religious belief one might kindly characterize as "atheistic hedonism."

One of the reasons I was so attracted to Unificationism was because it so smoothly integrated the scientific and religious areas of understanding.

A dispute

However, there is one area where Unificationism and modern science seem to thoroughly disagree, and that is the origin of species, in particular, the origin of the human race.

The science "text-book" explanation of origins—let's call it Darwinism for now—asserts that all species, including the human, develop through the gradual transformation of populations over an extended period of time by "natural selection" from variation developed by chance and accident. The key elements being "populations" and "chance."

Unificationism does not yet have a detailed theory of the development of species. However, it does explicitly outline the development of the human race (which could be generalized into a monogenetic theory covering the development of all species.) The theoretical structure of Unificationism is founded on there being a first man and a first woman and that God was involved in their creation. The key elements here being "a first couple" and "creative input."

Creationism

This conflict of ideas exists for all religions that are based on the Bible. Recently, some science-minded Christians have developed a system of ideas called Scientific Creationism.

To my mind, the great strength of Creationism is that it clearly delineates the areas of Darwinism that do not agree with "the facts"—which is the major sin in science.

I would encourage all church members with a western education to read at least one of the Creation Science publications to balance the dogmatic assertions of biology. Two most valuable books to read are "What is Creation Science" and "Scientific Creationism." (Master Book House, El Cajon, California.)

The great value of Creationism is that it shows the absolute necessity of including God in any theory of origins. However, it has not become an acceptable alternative to Darwinism in scientific circles because of two fatal flaws:

1. The theory gets caught up trying to prove that the creative effort of God occurred in a brief period of time—guided by taking the Bible liberally. There is acknowledgment that a belief in God's input into the development of the universe can be held without believing in 6-Day creation and Catastrophism (Noah's Flood to explain the fossil record.) However, the Creationism literature does focus on these aspects and it is an integral part of the theory.

2. There is no concrete theory of how God created or what actually happened? A bang? Or a shower of twinkling stars like Disney magic? Or a swirling in a mud puddle? No specific theories or mechanisms are postulated to enlarge or replace the concepts of Darwinism.

Unificationism, however, elaborates a Principle of Creation that outlines the process by which God creates.

Some people have mis-interpreted Unificationism to come up with an almost magical idea of origins themselves, perhaps because Reverend Moon once commented in 1964, "The parents of Adam and Eve were not

apes." Some have taken this to mean that Reverend Moon thinks that humans are not biologically connected to the apes.

This, however, does not follow. The word "parents" in Unificationism has a very specific meaning: A child has every quality and aspect—is a complete 'set'—of the parent. Even if Adam and Eve were created in the womb of, and born from, an ape, a Unificationist would not consider the ape as a "parent" as the human has many qualities lacking in an ape. Unificationism asserts that a human has all the qualities of an ape but, in addition, has a lot more—an ape is a 'sub-set' of a human.

The origin of form

Unificationism states that God is the source of the energy out of which the universe is constructed, beginning with the "Big Bang." The structure of matter—particles, atoms, molecules etc.—is now well documented by modern science.

However, there is an aspect of matter that is not dealt with by science, and that is the aspect of form. It is taken for granted that energy, and the "material" things it is formed into, does not behave in a random way. Instead, we find that there are patterns that can be mathematically described at every level of complexity. In science this patterning is called "natural law."

Some have argued that this pattern is the one that just happened to "freeze" out after the "Bang." Unificationism asserts, however, that this pattern—the Logos —is, along with energy, an integral part of God's creation and that the natural law exists before it has a chance to be expressed.

For example, the interaction of a proton and electron forming an atom of hydrogen. There is a very distinct pattern to this relationship which is the same for all the hydrogen atoms looked at so far in the universe. In the primordial "bang," before it is "cool" enough to form any hydrogen atoms, the pattern for hydrogen already exists. This is a general principle in Unificationism: The idea for something always exists before the thing itself. An understanding of the Logos and natural law are key elements of the Unificationist understanding of science—particularly evolution—and I shall explore the contribution Unificationism can make to scientific thought in further articles.

3. SCIENCE AS A GODLY PURSUIT

It was not until I was in my third decade that I realized that I had been tricked. I had been fooled into believing in something that did not exist.

And a whole slew of others who also passed through the hallowed halls of the British educational establishment were also equally fooled.

What was this phantom we were coaxed into placing our faith in. It is hard for me to admit it now—to expose myself to ridicule—but I must so that others can be warned and hopefully avoid the deceit.

We were taught to be believe in "material." To believe that material was the be all, and end all, of what was true and real. I was taught to be a materialist. And so were many others.

Bits of Matter

I am sure it will be a question that will stimulate great debate in the annals of historians who are, as yet, still only a potential in the genetic pool of the race: "How come so many people believed in something that is not really there?"

"Science," is perhaps your silent response to these future questioners, "It is science that has given us the secrets of Nature, the true nature of our material world."

But the more modern science you understand, the less and less you can use it as a foundation for a belief in material.

Now I don't want to make you feel insecure, but according to modern scientific understanding, whatever it is that is supporting you as you read this has a most tenuous, tenuous reality. It feels solid enough, you reassure yourself, but it's not. Not by a long shot!

Although such notions are not even as old as the United States—John Dalton of England put them on a firm footing in the first decade of the 1800s—scientists are convinced that everything material is made of atoms. That includes you and the chair (or whatever) you are reclining on. Atoms are so remarkably small that it is only recently—with technological advances such as the tunneling electron microscope—that they have been made directly visible. Even without this direct confirmation, however, most scientists for at least the last century have been pretty confident about the reality of atoms as it was the only explanation that made sense of all their experimental findings.

At first, people thought of atoms as the ultimate 'bits' of matter. But soon new evidence arrived that made this unlikely. It was Ernest, a chap (as the Kiwi and English would put it) from New Zealand who would one day hold the grand title of Baron Rutherford of Nelson, who undercut the idea of solid, material atoms. Through his work it became apparent that the atom had an internal structure. It turned out that atoms are made of tiny drops of remarkably dense nuclear material—a teaspoonful would weigh thousands of tons—circled by electrons which whiz around the nucleus at a ludicrous speed for something so tiny.

Nothing There

In air, atoms move so fast and bang into each other so forcibly that the atoms stay quite far apart. In liquids and solids, however, things are a little calmer and the atoms pile together like a bowl of peas. If you insist on taking the analogy any further (but please don't use it at the Academy of Sciences), then while the atoms in a bowl of liquid are similar to a bowl filled with thawed peas, the atoms in of a solid are in a state similar to that of a block of peas fresh out of the freezer.

It turns out that the 'bits of material' that seem to make up the atom are very much smaller than the atoms are. If you magnified an atom to the size of Grand Central Station, the atomic nucleus would be about the size of a contact lens and you still wouldn't be able to see the electron (which is 1/2000 smaller than the nucleus.)

If you ever lost a contact lens in Grand Central Station you don't need me to tell you that there's a lot of empty space inside the atom.

This means that if you removed all the empty space inside the atoms making up our planet Earth, you would be left with a monstrously heavy object the size of an orange. This compaction is not just a "suppose" type situation—something similar happens to elderly stars when they run out of energy and they collapse so that all that empty space between the electron and the atom nucleus gets squeezed out. The result is a neutron star and astronomers have already located quite a few in our own galactic neighborhood.

So why is the chair you are sitting in so reassuringly solid? The key is the tiny, tiny electron. Although small, it moves at such a speed that it circles the atom millions of times a second. Now as any housewife knows who has tried to fold clothes with dryer-induced static electricity, similarly charged items find each other quite repulsive. The electrons whirling around one atom are repelled, in a similar fashion, by the electrons whirling about another atom. This is the only reason why atoms seem—although we know that the are not—to be solid as they approach each other. It is only because the electrons in your rear and the electrons in your chair intensely repel each other that the chair feels solid. But, although the chair's not really solid at all, if you are going to have confidence in anything at all in this life it might as well be electronic repulsion as it has never, ever, been known to fail. And you can't say that about many other things in life, can you.

If the electrons in your body didn't repel other electrons then you could walk through walls, a convenient ability, but then you'd also fall through floors which is not useful.

Smaller Yet

So matter isn't such a substantial thing to believe in after all, according to modern science. "Even so," a determined materialist might respond, "Although it was not exactly what I was thinking of, that nuclear material is the 'real material' that I can believe in."

Recent advances in nuclear physics, however, are removing these remnants of solid ground from beneath the feet of the materialist view. As you might have guessed, it seems that the atomic nucleus isn't made of 'solid' material either; rather, it seems, it is made of even smaller components, the puckishly-named quarks.

If you magnified the smallest atomic nucleus (called a proton) to the size of the sun—a whopping 100,000 miles in diameter—a quark would still only be 1/10 of an inch across. And it doesn't take a lot of quarks to make a proton, just three.

Now if you took away all the space between the quarks . . . And if you took away all the space between whatever it is that quarks are made of . . .

You can see that science is heading towards an infinite amount of matter (or equivalently, as Einstein showed, an infinite amount of energy) tucked into a zero amount of space which is getting pretty close to what God is supposedly like.

You can guess where this leaves the Marxists and their "There is nothing but material . . ." Nothing but irrational, blind belief if you ask me. And many scientists seem to have their faith pinned on this something-that-is-not-really-there—this immaterial material.?

When we look at past scientists, however, we find that this blind belief in "material" was not always there.

Scientists

Now I have always been fascinated by science. I had my first chemistry set when I was 9 and had built up quite a decent lab in my bedroom by the time I left home for college at 17.

Also, in the sulfuretted dimness of the Bridgend Boy's Grammar School chem lab, I had learned from Trevor Thomas, my rugby-loving, Welsh-speaking chemistry master, all about the discoveries by the great men of science.

Now many of my fellow schoolboys had reluctantly parked their bodies there in blazer and gray flannel while their minds were out in the sunshine with friends and the thwack of the cricket bat. But I was fully there, enthralled by the simple beauty of the secrets revealed by those early pioneers of science.

So it was with delight that, while browsing through Scribner's Bookstore on 5th Ave, I came across a biography of Sir Isaac Newton with the entrancing title "In the Presence of the Creator." (Gale E. Christianson, The Free Press, Macmillan Inc. New York 1984) I made no effort to resist the impulse to buy it. It is a brilliantly written book and, as I read, Newton and his time took on flesh again for me.

Here was no atheist: "...the clockwork precision with which the universe functions is for Newton anything but the result of blind circumstance. For behind it all he sensed the presence of intelligible planning and purposeful direction. Under the heading 'God' he wrote 'Were men and beasts etc. made by fortuitous jumblings of the atoms there would be many parts useless in them, here a lump of flesh there a member too much...' This was more than a passing observation, it was a reminder to himself that the underlying unity in nature, revealed to man through rational inquiry, is a product of the Divine Mind."

These days, science is more often associated with atheism than with a belief in God. This is not a necessity, however, as much of modern science is very compatible with the theistic view of life.

4. ZENDING THE WRONG MESSAGE ABOUT THE NEW PHYSICS

Someone has to set the record straight! You might have noticed, over the years, a surge of books and articles—under the rubric of the Zen of Physics—asserting that modern physics is aligned with the core insights of oriental philosophy.

On the surface, this would seem like a Good Thing—cross-cultural interaction, inter-disciplinary pollination and all that—and just the sort of thing we might expect to happen during our millennial transition when the interminable rivalry of religion and science is destined to be amicably resolved.

While there are aspects of this East-West communion that are constructive—such as a reminder that, while science has succeeded by taking things apart, the whole is as important as its parts—there is a nasty blemish in this Aquarian synthesis.

The philosophical agenda

It is not the first time, by any means, that science has been used to promote a philosophical agenda, but the concord of the Tao and the quantum has been held up by a segment of Western society as a proof that the Christian concept of God is all bunk. In a nutshell, Christianity asserts that there is a standard of right and wrong because God created the world to function in a certain way through the physical and spiritual laws: follow the law and you prosper—health and happiness—break the law and you suffer—disease and misery.

For Christians, the Laws of God were equated with the laws described in classical physics which seemed to describe the way the material world functioned.

In contrast, Eastern philosophy—at least according to what might be called the West Coast school of interpretation—held that reality is flow-with-the-flow, everything is relative, good-and-evil are as natural as positive-and-negative, there is no rule of law, nothing is determined. This philosophy supports the idea that people have to create their own reality—I have to create mine, and who is to say that your preference is any better than mine—there are no rules, there is no God. (Yes, I know, I'm posterizing theological gray-shades into black-and-white monochrome but that's polemics for you.)

This conflict between "good and evil" and "do what thou wilt" has been going on for a long time: a masterly offensive in the struggle for the conceptual high ground was to co-opt the unrivaled authority of modern science. For, if modern science says that the natural world, at its very roots, is totally random and indeterminate, then who can doubt that there is no God directing things through His laws.

Thus has quantum physics been conscripted into the philosophical offensive against Christianity, for, at first glance, quantum physics maintains that, at a fundamental level, matter is indeterminate, there are no rules or laws at work. On closer look, however, we will see that this is actually a misrepresentation of the new physics—there are still Laws at work, they just aren't the ones the classical scientists thought they were.

Superficial quantum physics

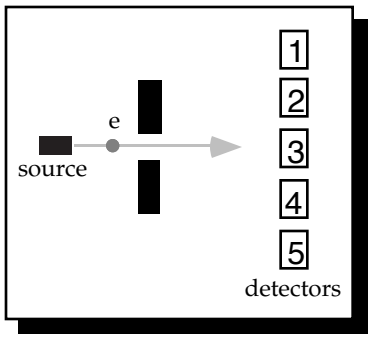
From Newton onwards, science moved from triumph to triumph with the concept of Natural Law—everything, it seemed, obeyed a set of deterministic laws. The majestic movements of the heavenly bodies, balls falling from the Tower of Pisa, sound, light, electricity —all had their behaviors encapsulated in a succinct equation that described the Law.

It was no wonder, then, that as modern physics was emerging at the turn of the century, it was confidently expected that the newly-discovered bits out of which all matter was constructed would also obey their own set of laws.

So it came as a big surprise when it was realized that the particles found inside atoms, such as the electron, did not exhibit deterministic behavior and follow a set of laws; rather, the subatomic turned out to behave indeterministically.

The essentials of this can be illustrated with a simple slit experiment: an electron is shot through a hole at an array of detectors. Which detector will fire? If it was a basketball being thrown at a set of hoops, the equations of gravity, wind, air resistance, etc., would do the job.

To summarize decades of struggle: it turned out that there was no set of laws at work; the best that could be done was to predict the probability of a particular detector firing. It is as firmly established as anything in modern science: it is impossible, in principle, to anticipate exactly which detector will ping as the behavior of all the fundamental particles involved in the structure of matter—electrons, quarks and photons—is inherently indeterministic.



Which one will the electron hit? According to modern physics, no one, not even God, can say.

Aha, says our West Coast guru, I told you so, at heart matter is fundamentally chaotic, there is no law running everything behind the scenes.

Unfortunately for our flow-with-the-flow friend, he has misunderstood—for while modern physics does say that nothing is determined about the externals of the electron, it has a whole different story about what's going on inside.

Inner space

One of the bedrock concepts of any scientific theory is the belief in an objective reality—there is something out there that is independent of the sense or observation that we can study and come to understand. Classical physics was very down-to-earth; it said that objective reality was the same as what we observed and measured—its position, its speed, etc. What you saw was what it really was.

While scientists are just as reluctant as anyone else to unnecessarily complicate their lives, over the last century they have been forced to reject this simple view of objective reality because it doesn't fit the facts. Currently, the accepted view is that the most significant aspect of the objective reality of subatomic particles—and, by implication, all the things made up of them—exists in an internal space, not the external space that we can observe or measure directly. As Prof. P. W. Atkins put it in his recent book:

"In a sense, the difference between classical and quantum mechanics can be seen to be due to the fact that classical mechanics took too superficial a view of the world: it dealt with appearances. However, quantum mechanics accepts that appearances are the manifestation of a deeper structure … and that all calculations must be carried out on this substructure" (*Quanta*, 2nd ed., Oxford University Press, Oxford, 1991, p. 348).

It would be a mistake to think that this "deeper structure" is what electrons are made of, digging into the structure; rather it is deeper in a 'direction' that is not along familiar dimensions of space and time, the external spaces.

This internal aspect to objective reality is called the "quantum state" of the object and, just as the phenomena in external space can be measured, so can the quantum state. The measurement of this internal aspect involves complex numbers; the regular ones are just not up to the job. As the name implies, complex numbers are a lot more sophisticated than the familiar ones. There are many things I could mention about complex numbers and why they are perfectly suited to the description of the internal state. A particularly interesting one involves logic.

Internal desire

One of the cornerstones of logic is the law of the excluded middle: something either is true or it is false, but it is not both at the same time. Shooting bullets at targets rather than electrons, we can be confident that either the projectile will hit target three or it will not hit target three—both cannot be true at the same time. Real numbers are just like this: for instance, we can say that this number is the same as that number or it is not the same—it is bigger or smaller than it.

The internal world, unlike the external world, does not follow the law of the excluded middle—it is quite possible to be two things at the same time. Anyone who has ever stood on the corner of 42nd Street and had a 100% desire to go uptown to Bloomie's and downtown to Macy's at the same time will have no difficulty in understanding this aspect of the new physics.

The strength of the internal tendency of the electron to follow a particular path and hit a particular detector (in our slit experiment) is called its probability amplitude for that path. Think of it as the electron's internal desire to go uptown. It is this that is measured by a complex number. Complex numbers are not suited to the black-and-white world of the law of the excluded middle; it is just not possible to say if one number is bigger or smaller than another—there are an infinity of different complex numbers, for instance, that can claim to be exactly the same 'size' as 1.

So the internal state of the electron moving through the slit is a mix of tendencies to hit the different detectors,

the so-called "supposition of quantum states." The electron has a probability amplitude for each path it could follow—hit detector 1, hit detector 2, etc. This set of probability amplitudes is called the "wavefunction" of the electron.

The connection between the internal quantum state and the external observable state is described by the relationship between the complex numbers and the real numbers: complex numbers have a projection, or an extension, in the real realm (called by a variety of names such as the absolute square, the complex conjugate, etc.). The internal probability amplitude has an external extension in the real world and this projection from internal to external is what we observe as the probability of the electron doing something.

The electron can remain in an internal mixed state only so long as it does not interact with anything. Interaction involves externals since all interaction is basically things swapping bits of themselves with other things. It's a bit like walking along 42nd Street: you can remain in a supposition state of desire for Bloomie's as well as Macy's as long as you don't go north or south—once you've taken even one external step either way you're committed externally and, unless you want to look stupid by abruptly changing direction, it's either Bloomie's or Macy's but not the excluded potpourri of them. The interaction of the electron forces it to 'choose' one external state or another and, in a process called "collapse of the wavefunction," the electron appears 100% at one of the detectors and not at any of the others.

So there is no 'law' making the electron hit a particular detector; rather it is the projection of its internal wavefunction as an external probability that's in control—if it sounds a little involuted, it is. It took dozens of people almost 100 years to figure it all out.

Inner reality

While the efficacy of quantum mechanics is not to be gainsaid, some scientists have a dreadful time taking it at its face value—perhaps a philosophical preference for materialism and a reluctance to put the internal world on a 'real' footing with the external world. As Roger Penrose noted—his emphasis—in his provocative book about the mind:

"Unfortunately, different theorists tend to have very different (though observationally equivalent) viewpoints about the *actuality* of this picture. Many physicists, taking their lead from the central figure of Niels Bohr, would say that there is *no* objective picture at all. Nothing is actually 'out there,' at the quantum level.... Quantum theory, according to this view, provides merely a calculational procedure, and does not attempt to describe the world as it actually 'is.' This attitude to the theory seems to me to be too defeatist, and I shall follow the more positive line which attributes *objective physical reality* to the quantum description: the *quantum state*" (*The Emperor's New Mind*, Oxford, 1989, p. 226).

What's wrong with the electron having a primitive mind, anyway? We're made of electrons and we've got one!

Now you've probably got the impression that the internal world of the electron is like its externals, all flow-with-the-flow and rather indeterminate—but nothing could be further from the insight of quantum mechanics. This is the bit that the "Do what thou wilt"-interpreter usually omits to mention—inadvertently or maliciously—the development of the wavefunction, the way it changes with time, is absolutely and 100% determined.

There is an absolute law that governs the internal world of the electron, and all the other subatomic bits, that is described by what is called the Schrodinger Wave Equation. This equation describes exactly how the inherent directive nature changes and develops. Unfortunately, this equation is fiendishly difficult to solve with current mathematical techniques. Some relatively simple situations, such as an electron and proton interacting to form a hydrogen atom, are solvable and are in perfect agreement with experiment.

Of course, knowing everything about what is going on in the mind of the electron still doesn't reveal exactly what it is going to do—all you can calculate are the probabilities of what it will do.

Presumably God is equally constrained; He can solve Schrodinger's equation with ease and knows everything about what goes on in the mind of the electron as it dances its dance. Still, omniscience has its limitations: even God can only know the probability of hitting a particular detector.

Sound familiar?

Classical laws

What about all those laws that classical physics discovered? you might be wondering, and all the stable structures made of electrons such as atoms, molecules, cells, etc. The answer is simple and also very familiar: freedom but no choice.

The electron interacting with a proton in a stable atom, for instance, behaves just as indeterministically as its unattached brethren, it's just that the influence of the interaction on the internal state of the electron is such that all the paths that lead the electron away from the atom have a zero probability while all the paths that keep the electron within the atom have high probability.

It turns out that all the deterministic external laws of classical physics are based on freedom but no choice—if something is 100% probable it appears, on the surface, to be determined.

If we liken the probability amplitude of the electron to the inner tendencies of more sophisticated entities such as ourselves, then we can say that the electron loses all desire to be alone—a striking resonance of the spiritual

insight that all things are imbued with the desire to serve a higher purpose (fallen man excepted, of course).

Quantum physics does not disagree with Christianity at all; God does work through His laws, but it was a mistake to equate these with the laws of the external world (such as Newton's gravity or Maxwell's electricity). The laws of the Creator work on the internal world, the realm of the inherent directive nature and the mind, not the external world of the body.

While the mind is predestined, the body is probabilistic. So, to be consistent, I'd better reword the phrase at the start of this polemic to the "millennial transition when the interminable rivalry of religion and science is internally destined to be amicably resolved and will probably be so any day now."

5. THE NEUTRINO AND THE BLESSING RING

I had been thinking for some time that I should write an article celebrating an aspect of the Blessing being held in Korea August 1992. And, as it's all I ever write about, I wanted it to have a science angle. But I was stumped as to just what to write about.

Then, just the other day, by chance or design I cannot say, I was discoursing with an encyclopedic academic about this weird and exotic subatomic particle called the neutrino. I had just finished telling him that, while the sun was pouring trillions of them down into his body at that very moment, he need not worry about it as they were so indifferent to him that they would all pass on through and, as the earth itself was as nothing to them—a trillion miles of lead would not faze them—they would pour on out the other side unchecked. Same thing happens at night, of course, except this time they pour in at the feet and out of the head.

At that point I would have recited the poem "Cosmic Gall" by John Updike if I had been able to remember it:

Neutrinos they are very small / They have no charge and have no mass
And do not interact at all. / The earth is just a silly ball / To them through which they simply pass...
At night they enter at Nepal / And pierce the lover and his lass
From underneath the bed—you call / It wonderful; I call it crass.

My erudite friend thought about this curiosity, for a moment. Then, being well versed in the Principle, knowing that God created all things with a purpose, he quite naturally asked, "What's the purpose of the neutrino?"

I paused for a Buddha-moment of Illumination as I realized he had revealed the topic of my article for me. "The purpose of the neutrino," I pronounced, "is the Blessing Ring."

More correctly, if less intriguingly, at least one purpose of the neutrino is the creation of all the elements heavier than iron, including the much sought-after gold.

The Big Bang

You see, when God created the Universe, He didn't make everything at once. In fact, just a few seconds after the moment of creation—what scientists with understatement call The Big Bang—all the matter in the universe was in the form of electrons, protons and neutrons. While the protons were stable and could wait around until things cooled down a bit to form hydrogen atoms with the electrons, the neutrons would fall apart into protons if left to themselves for longer than about eleven minutes.

In the ensuing few minutes, however, some of the neutrons hooked up with protons, forming helium nuclei, and escaped this fate.

So, the calculations of nuclear physicists tell us, when our universe was about an hour old, the matter it contained was about 80% free protons and the rest was helium nuclei.

Then, about a million years later, the universe had cooled enough and the separation period ended; the electrons embraced them and hydrogen and helium atoms formed. This was the first regular matter to appear and the universe still has, basically, the same composition today as it did back then—everything else is still just a minor constituent.

While this was a Good Beginning—it could hardly be otherwise—there was much to be done if the Plan was to progress, as it is difficult to build *anything* interesting—let alone the sons and daughters of God—out of just hydrogen and helium. Helium, in fact, is the "neutrino" of the atomic world—it is so indifferent to interaction that no one on earth even noticed it until its signature, so to speak, was noticed in the light coming from the sun. It took a little while longer to realize that almost a quarter of the universe is made of the stuff.

Hydrogen has a little more passion for give-and-take but, left to itself, about the most it can do is pair off into hydrogen molecules. Clearly, the work of creation had only just started.

The sun

Next step in the Plan was for the matter in the Universe, which at this point was pretty much a diffuse gas, to start clumping together under the influence of gravity. Just how this clumping occurred is currently a "hot topic" in the science world but, somehow, it happened.

Now you might have noticed when you were a kid that when you pump up a bicycle tire, the pump gets hot—compressing a gas heats it up. On a slightly larger scale, when trillions of tons of gas gravitationally fall

together they also heat up. As things progress, the gas gets very hot and, when the temperature gets high enough, a miracle occurs: a star is born. No, not the Judy Garland kind! That came much, much later.

This ignition occurs because the combination of a proton and a neutron has a little less energy than two free protons, so when two protons get close enough to each other they have a tendency, though small, to shake off that extra energy so that one of the protons transforms into a neutron and the two unite together, creating a heavy-hydrogen nucleus, a little bit of free energy, and a neutrino.

The energy that is shaken off in this union is called the "packing fraction" to remind us that, as you pack protons and neutrons together into more complex nuclei, a fraction of their mass is given off as energy.

What happens to the gas falling into the proto-star is that, at a temperature of a few thousands of degrees, the heat breaks up the atoms of hydrogen back into free electrons and protons. The proton-proton interaction, however, needs tens-of-millions since positive charges repel each other. It is only when protons are moving at very high speed (which is what we call hot) that they can overcome this repulsion and get close enough together to have at least a chance to pair up.

It is exactly this process that fuels the sun today—that energy we soak up when sunbathing (or used to before its dark side was revealed) was shaken off by such a fusion of protons. It's just as well that the tendency to fuse is slight, for if it were not, all the protons in the sun would pair off quickly and all the energy that the sun was planning to dribble out over the next five billion years or so would be released all at once—a hydrogen bomb to dwarf all man-made hydrogen bombs (which use the energy of an atomic bomb to overcome the reluctance of the hydrogen to fuse).

Just as hydrogen burns to form heavy-hydrogen, so heavy-hydrogen fuses to form helium—overall, our sun is burning its hydrogen to helium.

Big deal, you might say; there's plenty of helium in the universe already!

The light elements

This is where God gets really clever. You see, gravity, as anyone falling off a bed will tell you, is inexorable: it will keep on pulling you down unless something stops it. While the gas that originally fell together to form the sun would like to continue falling in to the center, the massive release of fusion energy at the center of the sun heats things up so much that its outward pressure prevents it. The sun is stable: the massive inwards pull of gravity is exactly matched by the equally massive outwards pressure of the high temperature at the center.

This phase is expected to last, as mentioned, about five billion more years. One of these distant days, however, our sun will run out of hydrogen. All the fuel in the center will be gone and the fire will go out. Gravity will seize its chance to continue what it was doing ten billion years ago, and the sun will recommence collapsing. This will increase the pressure and temperatures will rise and rise until they reach the hundreds of millions and helium burning will start.

I'll spare you the fascinating details but, in essence, helium nuclei, along with the occasional free proton or neutron, fuse together to create all the crucial elements that are needed for the construction of life: carbon, oxygen, calcium, etc., etc. All these light elements have positive packing fractions, so the helium burning releases energy. This release of energy halts the gravitational collapse, and the star reaches a new equilibrium.

This new equilibrium, however, is quite different from the old. The star becomes hugely bloated—our sun will engulf the earth—and massive amounts of material are ejected from the surface of the star into the interstellar space. Some of these Red Giants, as they are called, are called carbon stars precisely because they are pumping trillions of tons of carbon a day into outer space. All stars in their old age pump the heavier elements—carbon, oxygen, calcium, chlorine, etc., etc.—into outer space; they are the factories in which all the elements that living things are built out of are created.

Now, when new stars form out of the interstellar gas, there are small amounts of these materials present. In the process of the formation of our sun, some of the infalling gas didn't make it all the way into the center and remained in orbit . When the sun ignited, it blew off most of the light hydrogen and helium leaving behind the heavier stuff in orbit, an aggregation we call the earth. On this, the Plan—at least its physical aspect—was completed and life and the Children of God developed.

We, and the world about us are, literally, made of star stuff!

Heavy elements

This scenario, however, does not account for the gold and the Blessing Rings. You see, while the packing fraction of the lighter elements is positive—energy is given off when they are formed out of lighter elements—the packing fraction for all the elements heavier than iron is negative—energy has to be put into their creation. And gold is a lot heavier than iron.

We have gravity to thank, as it turns out. For our sun, the phase of helium burning will continue until that, too, runs out and the core of the sun becomes mostly iron surrounded by onion rings of the lighter elements that never got hot enough to fuse. The fire will go out and gravity will seek a new, and final, equilibrium.

The pressure that halts this final collapse is the reluctance of electrons to be too close to each other: the gravitational pressure is resisted by this electron pressure, and the shrunken sun, still immensely hot, will enter into a long senescence as a white dwarf until, as it slowly cools—the carbon layer, incidentally, turning into a huge diamond which will be useful for engagement rings if we ever figure out how to get at it—to the chill of outer space, it will enter eternity as a black dwarf.

There is a limit to what the electron pressure can take, however. For stars somewhat bigger than our sun at the time of their final collapse, the crushing inward pull of gravity overcomes this electron pressure.

The electrons have nowhere to go but into the protons, giving out, in the process, a neutrino (we're close to the gold now). All the matter at the center of the star converts into neutrons in a very short period of time, creating a never-yet-seen form of matter called neutronium and the core of the star transforms into a neutron star.

This sudden loss of the electron pressure causes the whole star to collapse rapidly inwards, releasing a vast amount of energy in the process which appears in the neutrinos. In regular matter, such neutrinos would escape carrying all their energy away, such as in the neutrinos created by the fusion in the sun which sail away perchance to pierce a lover and his lass. But neutronium, and the other exotic forms of matter created in the rapid collapse of the star, is not regular matter at all—it weighs in at a trillion tons a spoonful—and even neutrinos cannot pass through it with ease.

Much of the burst of neutrinos from the collapsing core is absorbed by these outer layers and dumps there a vast amount of energy. This causes these layers to blow asunder—the star explodes as a supernova and, for a while, it will outshine the whole galaxy of a million, billion suns. Some of the neutrinos do escape and six of them were detected when a star went supernova in 1987—six might not seem a lot but, for neutrinos and their reluctance to stop in the detector, it marked a massive flux of them passing through the earth from the dying star, even though it was trillions of miles away from us.

In the apocalypse of a supernova there is energy and more to spare—and iron, along with the other light elements, are slammed together with enough extra energy to create all the elements heavier than iron—including gold—which are then scattered throughout the heavens by the force of the explosion.

Gathered up with the lighter elements in the accretion of the planet earth, some of this gold, forged in the death throe of some ancient star, was lucky enough to end up on the finger of a child of God getting married.

So there you have it; neutrinos have their place in the Plan—for without neutrinos there would be no gold and, somehow, Blessing Rings of iron would not be quite the same. Congratulations all!

6. THEIST? DEIST?

This is an excerpt from a letter written in response to a philosophical inquiry, August 1992.

Reading my recent output, you might have gained the impression that I have lost my interest in evolution and have taken up physics instead. Nothing could be further from the truth! In my attempts to make sense of current evolutionary thought I came up against the concept of chance-and-accident over and over again. Eventually I became convinced that a fundamental misunderstanding of it underlay the apparent conflict between religion and science. It was the pursuit of this that led me into physics.

To my mind, some of the views you espouse in the paper you sent me verge on what you call (p. 12) "cosmogonic dualism" except that you substitute Natural Law for matter. You seem to imply that God is creating against a background provided by something else (God^2 perhaps?): "the origin of life was due solely to natural causes" (p. 4) as if natural causes were something not created by God but something He has to work around in getting things done.

I am convinced that much of our divergence of views, however, is resolved by the replacement of the now-outmoded classical view of natural law by the quite different perspective embraced by the new physics. In my exploration of this I have found there a quite different perspective on the role of Law and its mathematical description: one that is, to my mind, aligned with the conceptual framework of the *Divine Principle*—a most satisfying confluence of revelatory truth and experiential truth. To illustrate how I view creation, I give you, in the tradition established by Einstein, a thought scenario. Consider:

A rather small being not made of atoms—Maxwell's' demon (MD), perhaps, though in an unFallen state, of

course—is observing the universe sometime around a million years after the Big Bang. MD is contemplating the question: Is there really a creator God? And if He exists, how does He create?

Up until this time, the entire universe had been far too hot for atoms to exist and MD had never seen one. Just around the time he was musing on this question, however, things had cooled enough for them to exist.

MD is idly watching an electron and a proton approach each other. He has an intuitive grasp of classical Newtonian mechanics (though he doesn't call it that naturally) and he expects them to bounce around just like they always have before.

He watches in amazement, however, as the two settle into a highly-unlikely structured relationship. His grasp of the Laws of mechanics tells him that this is a highly-unlikely thing to happen. In that moment, he becomes a believer; he is convinced that he has seen a miracle—the Hand of God at work, ignoring the rules of mechanics, fashioning a totally new creation. MD has become, as you will say in the paper you will publish in 15 billion years or so, a theist; a creationist even.

Of course, MD has, indeed, seen God at work. But his perspective on the miracle is a little simplistic and unnecessarily mystical—it is quite understandable though no less awe-inspiring. There is an abstract extension to things, modern physics has discovered, that is causal to probability. This extension is not in external space but in an internal one—Decartes was in error, the mind does have extension. This internal aspect can be precisely described by mathematics. The coming together of the electron and proton to take up the characteristic form of the hydrogen tom, it has been found, is a function of this abstract aspect and is as "unmagical" as 2+2=4—actually, we would be more accurate, if more complex, to say that this particular coming together is actually as unmystical as $(2+2i) + (2-2i) = 4$.

MD doesn't need to invoke a miracle that he can never understand, he has witnessed one he <u>can</u> understand if he is willing to put in a little time studying quantum mechanics! When he has its basics down, he will realize that the probability of a cool electron and proton forming an atom is very high—he only thought the atom unlikely because he had an incomplete understanding of what chance-and-accident was.

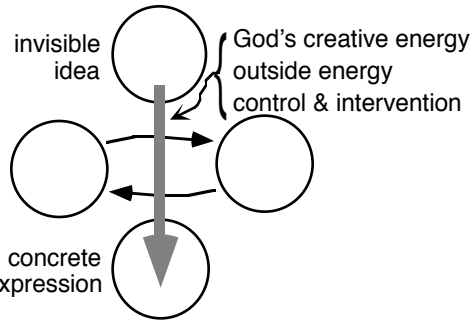
To imply, as you seem to, that there are aspects of God's creative process that are forever beyond our comprehension seems to be denying one of the central tenets of the Principle—that God created man in His image; not a partial pet-of-God but a complete child-of-God. Does this not imply that anything God can do, Man can understand? (Or, taken to its logical conclusion: do? Physicists are already speculating—in *Nature* no less—as to what it would take to create a universe. It wouldn't surprise me if God intends us to create life and nurture it through to perfection—and go through everything He had to go through!)

In the paper you sent me, I see that such views are classed as deistic—a view, you assert, held by a minority in the movement. I will grant you the numbers, perhaps, but you will have to concede there are some extra-heavyweights in the deistic camp as I would claim Dr. Lee. You quote from his *Explaining Unification Thought* (p.13) the statement that <u>all</u> the creative activity occurred <u>before</u> the Creation was begun in the design of the Principle/Logos. In his development of this, Dr. Lee places great emphasis on the autonomy of the Logos in ordering the physical world—a deistic concept if ever there was one.

I think it is important to remember that the very foundation of God's Plan is to create beings like Himself, and that the only way to do this was to make Man the Lord of Creation; for Man to be <u>really</u> in charge, not just as a result of a hands-off policy kept by God that could be changed at a moment's notice. My understanding of the Principle would be that God designed the world so that He can only do miracles through the agency of a human being. Here we differ again—you will allow miracles before the advent of Man, I will only admit them after!

In your article, you quote many Unificationist sources, including Father, to invoke a somewhat undefined "input" from God— "God's creative energy", "outside energy", "controlled or intervened" (p. 12, 13). All of these quotes, however, are just references—in rather general terms, admittedly—to the only power that is attributed to God in the Divine Principle. This is <u>not</u> the power of moving bits and pieces of matter around at will; it attributes to Him no magic wand à la Disney's Good Fairy.

The only power that the Principle ascribes to God is that of Give and Take action. It's right there in DP 101: through give-and-take action the invisible idea is given concrete form. You can, of course, speculate that God has other powers, but I don't think you can claim them to be a part of the Principle!



This is exactly how we know God created atoms. Here we have my pivotal thought about evolution—I am convinced that the origin of species is qualitatively the same as the origin of atoms. I am currently in the process of making a case for this view and I have high hopes of doing a good job of it.

Categorizers of creation views fail to take into account the fundamental paradigm shift in modern science: in classical physics the Laws of Nature were thought to act on the external aspect of systems to make them do things. It is this concept that Darwin rejected—nothing <u>made</u> the eye develop. The new physics, however, has completely done away with this concept. The Natural Laws work <u>only</u> on the internal level (the aspect of the electron, for instance, described by the probability amplitude). There are no laws, in modern physics, to rule the

externals.

There is still determinism—God's Law does rule the creation—but it only works on the internal aspect. Schrödinger's wave equation, for example, is totally deterministic and allows the quantum state to be precisely known at any point in the future. The expression of this internal aspect is what we observe as probability. As I rather bluntly put it in a recent article—not even God can tell which path an electron will take, but He does know exactly the probability.

The influence of the internal Laws on the external course of a history is purely probabilistic. The Laws do not make an atom form, they just make it highly probable—neither do they make an eye form, they just make it highly probable!! I'm not sure where this falls in your classification of views: the probabilistic form (of atoms, molecules, cells, organs etc.) is designed but their creation is contingent—an atom will only form if an electron and proton happen to be in the vicinity of each other, for example.

As you rightly recognized, what you read is a work in progress. What has been most encouraging in its development is that, although I have made no attempt to "squeeze" modern science into a Principle framework, the basic concepts have all emerged naturally in my attempt to make sense of all the material I am encountering in my studies.

7. Russians Ask Questions on Science & Religion

Clearly this year of 1992 is going to be very dynamic—just one of the many exciting things that are to happen is the Divine Principle workshop for thousands of Russian students now being held in the Black Sea region. I was talking to one of the lecturers at the last workshop there and he mentioned that, because of the combination of an atheistic upbringing and an excellent educational system, many of the students asked challenging questions of their lecturers about the areas where science and religion overlap.

He thought it would be helpful if I could provide him with some meaty answers to some of the most frequently asked questions. These are the questions with the answers I provided. He plans to take them with him; I can only hope they were of some use.

How can we reconcile the idea of God with evolution?

The role of selection in evolutionary theory is firmly established: characteristics that enhance the reproductive success of individuals in a lineage prosper, those that diminish do the opposite. This is commonly paraphrased as "survival of the fittest" and is not (or should not be) a problem for any theology. What is not at all clearly established in science is the *origin* of the characteristics that are to be sorted out by selection. Being unknown, scientists are free to speculate and often ascribe their origins to the workings of the little god of 'random-chance-and-accident' while, clearly, those of a more theistic bent would like to see the hand of the real God at work.

In text-book classical evolutionary theory, the source of new characteristics is ascribed to random mutation. This perspective is based on the physics of Newton that describes the motion of matter as being determined by the influence of "blind forces" such as gravity or electromagnetism.

This deterministic foundation to classical evolutionary theory, however, has been rejected in physics—though the change has yet to reach "textbook" biology. In quantum physics, determinism is an artifact. The motion of material, in the new physics, is probabilistic and is a function of the so-called internal spaces of particles such as the electron (roughly equivalent to the Inherent Directive Nature).

This probabilistic perspective has moved up the scientific hierarchy and is now well established in chemistry. For example, the interaction of an electron and proton to create an atom is a function of a probability field that has an abstract form to it (called an "orbital"). The external form of the atom is known to be a reflection of this abstract probability form. Similarly, the form of molecules is a function of a probability form that governs the movement of atoms.

Science is reductionistic: this means that what holds for electrons and atoms also holds for things made up of electrons and atoms. So, while the probabilistic concepts of the new physics have not yet been incorporated into biology or evolutionary theory, the same principle applies: the forms of living systems are also a function of abstract probability forms.

Just as the physical "evolution" of free electrons and protons into hydrogen is governed by a probability form (orbital) so the biological evolution of living systems is also governed by abstract probability forms.

The concept of 'abstract probability form' used in modern science can be equated with the religious concept of an 'idea in the Mind of God.' In this sense, then, the new physics supports the religious perspective that evolution is guided by God's ideas and that the living forms that emerge in evolutionary history are a reflection of these ideas.

How can we reconcile the first humans arriving un-evolved with the theory of evolution?

The physical and spiritual origins of humans are quite separate. Science deals solely with the physical origins.

It is very firmly established that the physical lineage of humans is connected to that of the apes and, eventually, to all living things. The evidence for this is overwhelming that any religion that wanted to deny it is

doomed to ridicule. Just two examples: 1. the genetic endowment of a human and a chimpanzee are 90% identical—not similar, identical. 2. the codes that humans, animals, plants and bacteria use to translate DNA information into protein are exactly the same.

The basic principle of evolution is that the origin of a system (be it an atom, a cell or a human being) involves a rearrangement of already-existing systems. This rearrangement, as discussed above, is not disordered but is governed by the form of abstract probability fields.

The rearrangement that occurred in the physical origin of human beings involved the shuffling of genetic systems already present in ape lineages.

This shuffling of genetic systems is called 'recombination' and occurs in a mild form during sexual reproduction. In this process, bits of chromosomes from both the male and female parental lineages are spliced together to create a brand new chromosome—though it remains a human-type chromosome. This is how children come to reflect a mixture of characters from the parental and maternal lineages; a process called micro-evolution.

For many years, the mechanism driving this chromosome splicing was unknown and thought to be very simple. Only recently has it emerged that such mixing of chromosomes is under the control of a highly sophisticated control system in the nucleus that is not at all random but probabilistic.

A similar, though more drastic, process can mix up bits of chromosomes to create entirely new types of chromosomes—and hence, new types of organisms. This is macro-evolution, the origin of species. When this process goes awry, gross birth defects occur which is why this evolutionary scenario has been labeled the "hopeful monster."

There is also speculation that viruses might be involved in these dramatic changes: they have the ability to alter the development process (German measles during pregnancy is a destructive example of this) and the potential ability to transfer genetic material *en mass* from one person to another (bacteria use this process to rapidly evolve: an example is the spread of resistance to antibiotics from one bacterial species to another using virus carriers.) This is speculative at this time but, if true, then viral diseases are bodily functions gone awry and not parasitism (as it clearly is in the case of bacterial diseases).

In this perspective, speciation is a dramatic change that does not occur in many lineages at many different places; it is something that happens once in a lineage (or even a convergence of similar lineages).

Human origins, as envisioned by Darwin, involved widely distributed large populations gradually diverging from apes to man. Recently, however, research into DNA transmission down a lineage has shown that all humans are descended from one woman in Africa 3–700,000 years ago (the so-called mitochondrial Eve). Interestingly, linguistic studies have shown that all languages can be traced back to a proto-language of a similar vintage. Such work supports the currently emerging view that all humans are descended from a "small population" in Africa.

Physically, then, humans are qualitatively similar to apes—they can speak, sort of, walk upright, clumsily, and manipulate tools, on occasion. All religions, however, assert that humans have more than just the physical aspect and that the origin of the first humans involved the emergence of a spiritual aspect that is not present at all in the ape lineage—apes do not create proto-civilizations, or have simple conversations about life-after-death, or write bad poems.

While the physical aspect of man is as much a product of evolutionary processes as an oak tree, the spiritual aspect is not. This is why apes are not called the "parents" of humans; while they provided the physical attributes, the rest—the important part—did not come from them.

How can we say only man is not ideal when nature is full of conflict?

The physical world is finite and (even for God!) it is not possible to conceive of a way it can work without cyclical change; one thing turning into other things. For example, if dung did not decay we would be miles deep in it by now! Grass turns into deer, deer into lion, lion into carcass, carcass into grass. The 'conflict' of a lion killing a deer serves the larger ecological cycle. If we find the process of the kill repugnant, it is quite within our power, as stewards of creation, to create gardens in which lions are fed painlessly-killed deer: no fuss, no mess, and the cycle continues.

Animals are designed to work well with relationships based on might-is-right—the strong lion eats the weak lamb, the strong grass absorbs nutriment from the decaying lion, the strong lamb eats the weak grass. It all works very, very well. Evidence for the more-than-animal nature of humans is that might-is-right does <u>not</u> work well as a way of life. Even the most primitive of societies introduce abstract laws to guide their social relationships as only misery results when spiritually-immature humans try to live by the physical principle that serve the rest of nature so well. Humans are actually designed to work well together only with a fully developed spirit—big hearts and big minds.

How can we say that all things have complementary polarity?

Polarity is important for relationship; what science calls interaction. In classical physics, interaction was thought to be the result of abstract fields of force—electromagnetism and the like. It was discovered this century, however, that interaction always involves things exchanging other things. For example, electric charge turns out to be the ability to give out or take in bits of light energy (photons) and the electric interaction is the exchange of

these packets—one gives it out, the other takes it in. This is true for gravity (exchange of gravitons), the valence interaction of atoms (exchange of electrons), as well as the more complex interactions that involve the exchange of atoms, molecules, etc., etc.

The one that gives out or initiates is called the subject, the one that takes in or responds is the object. These are not to be confused with plus and minus—a negative electron and a positive proton are equally able to emit or absorb packets of light so, in a sense, they take turns being the subject or object in the exchange.

Without such an exchange everything is static, only with exchange is change and development possible.

For example, biologists wondered for many years why almost all organisms use sex when asexual reproduction would seem to be a lot more efficient. It turns out that asexual development is an evolutionary dead-end as there is a strong link between the mechanisms of sex and evolution (see above). The environment is constantly changing and lineages have to be able to adjust in order to survive. Sexual reproduction is usually sufficient, but occasionally things change so rapidly that only massive changes—the origin of new species—are sufficient to stay ahead of the game. This is called the "Red Queen" concept in evolution after the matriarch who told Alice that, in her world, you had to run as fast as you could to stay in the same place. Most lineages, it has been found, persist for millennia unchanged, a tranquillity punctuated with bouts of rapid speciation—the concept of "punctuated equilibrium" that is now being widely embraced.

Is there any scientific evidence for spirit world?

There is no direct evidence for spirit world, it is only indirect. This is not scientifically hopeless, however, as it is also true for many things accepted as real by modern science but not directly observable: the invisible 'dark matter' that makes up 95% of the mass of our universe, the gravitons predicted by quantum gravity, the quarks that make up the proton and neutron, and the internal space of the electron that give it its probabilistic nature, to mention just four. All these are 'believed in' even though the evidence for them is indirect and circumstantial. Similar evidence for the spirit world that is difficult to explain if humans are "just animals" includes:

1. Medical research compilations of thousands of near-death experiences.
2. The qualitative difference between humans and apes.
3. The aspects of humans that transcend the physical situation (exemplified by Jesus on the cross)
4. Emergence of similar concepts of life after death in all cultures when the "evolution" of such a universal desire for immortality would not be expected if it was impossible.

This last answer is a little weak, but then there really is no 'proof' of spirit world—the best answer is to have your own direct experience of it. Scientifically, however, one interesting aspect of out-of-the-body experiences is that sight are retained are retained; people see and hear what is going on around their body. Both sight (the absorption of photons) and hearing (pressure waves transmitted by the electrostatic repulsion of atomic electrons) involve electromagnetism which is also responsible for the solidity of the physical world—yet the out-of-the-bodier can pass through walls and not be seen or heard. Something's missing here. Any ideas?

8. Baking a Universe the Hard Way

Barring a few dissenters, I think I can speak for the majority and assert that both scientific and religious people agree that the universe we live in originated out of nothing. This is what theologians, with their delight in Latin phrases, call 'creation ex nihilo.'

Scientists basically have one theory as to how this ex nihilo happened, they call it the 'Big Bang' theory. (The few who do not agree are considered 'fringe' or worse.) Religious people, on the other hand, can be divided into those who think He created the universe the easy way and those who think He did it the hard way.

The easy way is similar to the method used by the Good Fairies in Sleeping Beauty. My three-year old son has watched the Disney cartoon so many dozens of times that I have had plenty of chance to study how they do it. The secret is in the wands. When they wave them a misty sort of rainbow leaps from the tip filled with glowing sparks and a cup of tea or a sword appears.

This, compared with the usual way of making a cup of tea or a sword, is the easy way of creation.

I think that many religious people assume that God created the universe the easy way (with or without the misty rainbow and sparkles.) The creationist movement embraces this way of thinking. They take "And God said, 'Let the earth bring forth creatures ...' And it was so." to imply the easy way of doing things—Lions and tigers and bears etc. just popped into existence. Essentially, this viewpoint has God saying a word or so (without going into the theology of how God can speak without a mouth) and that the universe promptly responds to this command.

The hard method of creation is quite different and involves mathematics. (I know you probably dislike math, but please persevere, I promise not to use any equations!)

Cosmic Math

Why mathematics? The reason is simple: The universe is nothing but relationships, and math is simply a convenient shorthand for describing relationships. In science, one prefers the term 'interaction' rather than 'relationship,' but modern science is very clear about one thing, when you remove the interactions in material you end up with very little. Without interaction the whole universe could fit inside a pinhead with loads of room

to spare (which it actually did for the first few microseconds of history.)

So the universe is relationships and so is math. This is why, even when you study the most difficult and exotic areas of math (and believe me, there are plenty), you will always find the familiar ' = ' symbol which simply says that whatever the symbols on the right hand side create by their relationship is the same as what is created on the left hand side. This is why math is perfectly suited to describing the intricacies of the real world, math and reality are constructed in the same way, one is symbolic relationship, the other is 'real' relationship. (Math, by the way, can be considered larger than reality in the sense that it can explore relationships not encountered in the real world, such as E = mc without the square)

In this view, the 'word' of God is mathematical. God figures out the relationships that will rule the material world and accomplish His purpose before He sets everything going. (Of course, God also has to make sure that material obeys the law, but that is another topic for another time.) This is the hard way to create a universe, but this is the way all scientists and some religious people think it was done.

These relationships are what we call 'natural law' and this is why natural law can be expressed in mathematical symbols. (A source of great annoyance to those adolescents in science class trying to burn into memory such gems as F = ma, V=IR, k=PV/T etc. etc. etc. and these are just the simple ones from the early days of science; equations these days have multiple integrals and complex numbers to name but a sample of the mathematical repertoire needed by the modern scientist.) The world in all its richness and beauty is constructed on a mathematical foundation, whatever else God is, He must be a Great mathematician.

So, if we can agree that creation ex nihilo was done the hard way, our next challenge is figuring out how it happened?

To bake a universe, take . . .

The interesting thing about this question is that it is not so much a problem for science as it used to be. In the early days of science, matter was thought to be made up of little balls of stuff, and it was very difficult to see how bits of matter could just pop into existence out of nothing (without reintroducing the magic wand), because everyone thought that nothing and something were so very very different.

Something out of nothing is no longer a problem for science because it has been discovered that something and nothing are actually very similar, one can change into the other very easily.

An excellent and accessible overview of how science has solved the problem of something from nothing is "The Creation of Matter" by Harald Fritzsch (Basic Books, NY). He offers an illuminating analogy: Take an extraordinary oven that can be set to any temperature you wish (extraordinary in the sense that it doesn't melt whatever the temperature.) Remove every single atom inside so you have absolutely nothing inside. Our challenge is to see how we can make some matter out of this nothingness.

Even before turning on the oven, the inside is not quite empty as there are a few particles (photons) of very low energy electromagnetic radiation (radio waves) zipping about inside. But this is as empty as one can get. Turn the oven on. As the temperature rises, two things happen: the particles of light get more energetic and there are lots more of them as every time the temperature doubles you get sixteen times more light. By the time the temperature of the oven has reached a few thousand degrees the radiation is energetic enough to be perceived as light and the oven is brightly glowing a cherry red. By the time the temperature reaches the millions of degrees found deep inside the sun, (no ordinary oven, remember), the radiation is mainly as X and gamma rays—lots of them.

. . . set the oven to high . . .

So far we have only created light which is not really 'something' in the material sense. When the temperature gets up to six thousand million degrees (a temperature only reached in the universe these days for a few minutes during the supernova explosive death of a massive star), something quite surprising happens, some of the high energy gamma rays spontaneously turn into an electron and an anti-electron (positron), a process called 'pair-production.' This is a real case of 'matter out of no matter' as the electron is one of the three ingredients of everyday material. (The anti-electron is one of the constituents of anti-matter, something I will return to before we end.)

So just by raising the temperature, we have filled our originally empty oven with huge numbers of photons, electrons and anti-electrons (and other exotica but I'm sure you don't want too much detail).

Continue to stoke the oven. When the temperature reaches ten million million degrees (roughly the energy levels of our largest particle accelerators) another type of pair production starts up, protons & anti-protons and neutrons & anti-neutrons pop up all over. Protons and neutrons are the other two constituents of regular matter so our oven is now filled with all we need to make matter. Lots of it as well. There are now so many particles in our originally empty oven that the density is a hundred million million million kilograms per liter. This is 'something out of nothing' with a vengeance!

Naturally the pressure inside the oven is tremendous and if the oven collapses there will be a tremendous explosion and the contents will rapidly cool off. Can we expect to have 'baked' a few quintillion tons of matter out of nothing?

Up until just recently, the answer to this was 'no' because, while our hot oven is chock-a-block full of matter it is also just as full of anti-matter, exactly one for one. And matter and anti-matter annihilate each other on contact, turning back into light. In our hot oven this is no problem as both are forming just as rapidly as they are disappearing. But if the oven cools, then the annihilation predominates and, by the time we are ready to open the door to see what we have baked, there is absolutely nothing left at all. Not one single atom. This seems a poor recipe for baking matter.

So on solid experimental evidence, it seemed that the Big Bang should have produced equal amounts of matter and anti-matter (if anything at all). But our universe is made entirely of matter while anti-matter is a laboratory curiosity (which is why you probably haven't heard much about it).

But we did create matter. We did bake something out of nothing even if it did end up flatter than a failed soufflé. How could we have accomplished this seemingly miraculous appearance of tons of matter out of nowhere. The answer to that one is not to be found in cosmology, it is only to be found at the frontiers of modern physics. These frontiers are dealing with energies so immense that they are forever—well, a long long time anyway—beyond the reach of experimental testing. The only time such energies appeared in this universes—and where theoretical prediction can be tested by its implications on—was during the first instant of creation.

The only theories that are successfully dealing with these almost inconceivable energies are the superstring theories, one of a variety affectionately called, Theories of Everything (TOE).

. . . and add a twist.

Clearly, any theory that deals with baking matter out of nothing will have to explain clearly how matter and anti-matter appear out of nowhere. This oddity is explained so neatly in Superstring Theory that, although I hate to say it as so many have placed their errors into print, it just has to be true.

This theory has theoreticians excited because superstrings also have the ability to unite those two great—but thoroughly disunited—pillars of modern physics: Relativity, which showed that gravity is a bending of our familiar four dimensions of space-time; and Quantum Mechanics, which accurately describes the behavior of the subatomic world without saying anything about what it's made of.

The two basic concepts of superstring theory do not make common sense (so you will not be alone if this section makes you wonder of modern physics has got a little out of touch with reality): the universe has many dimensions to it in addition to the regular four; and that there is another variety of gravity called 'supergravity.'

Einstein has everyone convinced that everything about gravity can be understood as a curving of space-time. Space-time is just the four familiar dimensions of left/right, up/down, forwards/backwards, and past/future. To a scientist the only difference between the spatial dimensions and time (which seem distinctly different to us) is that space is described by real numbers and time by imaginary numbers.

Just as to what these dimensions really 'are,' no scientist will yet speculate (although the philosophers probably have lots to say about it.)

You can curve a 1-dimensional wire, you can curve a 2-dimensional piece of paper, you can curve a 3-dimensional eraser and, as Einstein has everyone convinced, you can curve 4-dimensional space-time.

Energy and mass (Einstein showed they are the same thing) are what curve space-time and it is the experience of this curving that we call gravity.

Regular gravity is a wimp. A toy magnet can lift a piece of iron against all the gravity of (the local curvature caused by) the massive earth. Outside of stars and black holes there is hardly a dent in the immensities of space. Regular gravity is so mild that all the matter in our universe hardly bends the familiar four dimensions at all, the curve is so gentle that it is hardly noticeable over the whole vast expanse of the visible universe (otherwise you'd see Australia looking up into the night sky.

Superstring invokes the existence of at least 10 (and perhaps more that thirty) new dimensions in our universe. The reason, they say, why we are so unaware of this extra ways to move around in is because of Supergravity. Supergravity is just the opposite to its wimpy cousin. It is so intense that it bends all the other extra dimensions so fiercely that they end up billions of times smaller than even an atom. These bits (or strings) of rolled up dimensions are what we see on a gross level as subatomic particles. (Naturally, you will ask at this point, 'Just what are those extra dimensions?' Here we come up against the limit of current understanding, no one knows—but then no one knows what the familiar space and time dimensions are either.)

Why our comfortable four thankfully escaped this crushing fate is also a mystery.

Superstring theory explains how everything we observe about particles are actually twists in these bits of higher dimensions. For instance, the two varieties of electric charge, positive and negative. You will not be too far off the superstring path if you think of them as tiny twists in one of the higher dimensions, a left-hand twist being one charge and a right-hand twist the other.

This might sound a little weird and abstract but it does explain a great deal. When an electron with a negative charge meets an anti-electron with a positive charge they turn into particles of light with no charge. This is simply a left-handed twist meeting a right-handed twist resulting in no twist at all (at least in regard to charge).

The spontaneous creation of matter and anti-matter out of nothing is just the reverse of this. Sufficient energy can twist the higher dimensions and it is these twists, remember, that appear to us as particles. But common sense (it has its part to play and it's backed up by topology, the study of shapes,) tells us that any twisting of an untwisted state will always involve a left-handed and a right-handed twist going off in different directions. If you (or, more likely, your kid) has ever pulled the tape out of one of your (probably most precious) cassettes, you will know that twisting always produces matching twists with opposite directions which, with care, can be brought back together to make no-twist once more.

The creation of such complementary twists in the higher dimensions by energy are what we observe in our regular dimensions as matter and anti-matter particles popping out of nowhere.

Making sense of the mystery of the ex nihilo creation of matter/antimatter still leaves us with the flaw in the recipe, equal amounts of each 'twist' get created and they mutually untwist as soon as possible.

. . . crumble it with the left hand . . .

It is only recently that a possible solution to this final problem has emerged. And, of all the oddities we have yet encountered, this is probably the least expected. The answer was found while modern theoreticians were searching for beauty in modern physics. This fascinating search is well documented in Anthony Zee's, 'Fearful Symmetry: The Search for Beauty in Modern Physics.' (Macmillan.)

As with superstrings (which can be very beautiful to a physicist), experiments in the realms of this quest are beyond the reach of current technology, so the answers are pure speculation based on the somewhat esthetic logic of symmetry. This logic is called group theory and you need a Ph.d in math to even get close to it.

So, to cut a long story short, we can summarize their conclusions as a belief that things are basically simple. For instance, the idea that there are four forces in nature (gravity, electromagnetism and the strong and weak nuclear forces) is not 'beautiful. Just one would be a lot more 'beautiful.' But group theory tells the searchers after the Grand Unification Theory (GUT) that the only way to bring them all together is to introduce a new particle (well two actually but how much detail do you want) called the X particle which, confusingly, have nothing to do with X rays. (One interesting corollary of the existence of this X particle is that matter might not be quite as stable as we thought it was. This is why some scientists are watching millions of gallons of water deep in abandoned salt mines hoping to catch a proton in the act of falling apart. If they do, you can bet it will make the headlines.)

The only reason that we don't see the unity of all forces and this new X particle is that the universe is so very very cold. This is not a problem for our oven so we can just turn up the heat some more.

At a temperature of ten thousand million million million million degrees the X starts to appear out of nowhere. Along with this twist, naturally, comes a counter-twist, the anti-X particles.

Incidentally, at this point our originally empty little oven is so truly stuffed that each pinhead point now contains more matter than our entire universe. (This ex nihilo trick is simpler than you probably thought possible.)

The X is a truly massive particle which falls apart rapidly. Up until this point, matter particles have behaved identically to their anti-matter equivalents. Not so the X. One of the forces involved in the breakup of the X particles shows a distinct preference for what a physicists would call a 'parity violation' and everyone else would call being 'left-handed.' This is quite unexpected, as almost everything else in physics shows no preference for the right or the left. This left-handedness can be considered evidence of creative fiddling with the rules of the universe because, as we shall see, it is crucial to the universe being more interesting than just a blaze of light.

The crucial result of this left-handedness is that, for once, matter and anti-matter behave differently. An X particle falls apart into two U quarks so we might expect an anti-X to fall apart into two anti-U quarks, but it doesn't. Because of that unexpected left-handedness, an anti-X falls apart into an electron and a D quark. So an X and anti-X fall apart into three quarks—two U and one D—and an electron.

So what, you might think if you've made it this far. The incredible cosmic far-out significance (one really can't over exaggerate at this point) of this little fact is that two U quarks and a D quark make a proton, and a proton and an electron make a hydrogen atom. So a pair of X's fall apart into everything we need to make atoms. And atoms are real matter.

It is this left-handed crumbling of the X pairs that makes the baking recipe work because, if our oven explodes at the temperature where pairs of Xs are being created, those particles will leave behind them a small number of protons that are not matched up with anti-protons and an equal number of electrons that are not matched with anti-electrons. Now, as the temperature falls and the matter and antimatter particles fulfill their suicide pact and turn into light, there are a few protons and electrons left over to form hydrogen when things really cool down. This is the key to the recipe for baking matter out of nothing.

All the matter in our universe is the result of this slight excess of matter over anti-matter. And it was a very slight excess. The matter made in the Big Bang was almost all hydrogen and for every hydrogen atom created over ten thousand million photons of light were created at the same time. "Let there be light" is no exaggeration! Without that built-in left-handedness, the history of the universe would have ended right here, light and nothing else but light. Pretty, but boring.

Of course, hydrogen alone does not an interesting universe make. But you can bake hydrogen in the center of

stars into all sorts of interesting things such as oxygen and carbon, the stuff of which we dreamers are made of, so it's a good enough beginning.

It is known that the universe was much hotter even than this ridiculous X-creating temperature in the very beginning, way up in the quilly quintillion range and higher. So it is quite scientifically respectable to think that God (perhaps the Heavenly Mother aspect?) simply baked this universe out of nothing. The starting point seems to have been an infinite energy potential, but this is something currently beyond scientific speculation as even the best theories fail to even speculate about the universe before it was a million trillion trillion trillionth of a second old. What was happening before that time is currently part of the great unknown.

THE COSMIC RECIPE

It took a while to get here and, what with X particles and higher dimensions, I can only hope you made it. But here you have it, science has uncovered a possible recipe for baking a universe: Take empty space, set the temperature on high, add a little twist and crumble it with the left hand.

Did I say that this was the hard way to make a universe? If you ask me, it seems a lot easier than figuring out how to make a magic wand.

9. GETTING CLOSER TO THE MAIN EVENT

While many religious people seem to be moving their focus from the metaphysical realm to that of the material—the rise of social consciousness —many scientists are moving in the opposite direction, abandoning the realm of material for something a lot less substantial. Recent developments in fundamental physics are a good example of this trend.

The most stimulating developments in this field these days involve what physicists call the Theory of Everything. (Do note, however, that this is the physicist's view of everything which only deals with the basic stuff out of which our world is constructed. In a strictly reductionist universe, of course, this would be sufficient—if you know how every cog works then you know how the whole machine works. The universe doesn't seem to work that way, however, but it is still a great advance to clearly understand the fundamental stuff of the universe.)

This is the great hope that physicists have in the Theory of Everything (TOE), that it will, for the first time, provide scientists with a complete description of the 'cogs' of our universe.

The surprising thing, however, is that the great advances in this theory are being guided by a metaphysical belief, that there is one single explanation for everything and not two, three, four or more of them. Furthermore, this TOE is expected to explain the origin of the universe (without saying, "God did it," which is not allowed as an explanation.)

The Problems

It is this belief in unity that is spurring on many of the great minds of our generation because, for all the remarkable advances in physics this century, there are still some major problems that have defied solution. I'll try to give the gist of what is happening, but if you want to delve more deeply, I can recommend a very accessible book, The Moment of Creation (James S. Trefil, Collier Books, New York.)

The biggest problem facing physicists is that while the theory of relativity perfectly describes gravity and the large scale structure of the universe, it is quantum mechanics that perfectly describes electro-magnetism and the other forces involved in the small-scale structure of the atom. Everyone in the field has tried his (and her) hand at reconciling these two theories but nobody, including Einstein, has been able to tie the two together.

Another problem is that while quantum mechanics works well, it only does so if you cheat to avoid the calculations exploding into infinity all the time (physicists don't call it cheating, of course, they call it 'renormalization' which sounds a lot more professional.) The awkward thing is that there is no good justification for the cheating (other than it works) which, naturally, gives physicists the sneaking suspicion that they are missing something important somewhere.

Another challenge is the basic cog of the universe, the fundamental particles out of which all matter is made. When the first atoms were 'split', it seemed that there were only three truly basic bits of matter, the electrons, protons and neutrons. Then for a while, with the advent of the very high-powered atom smashers, it seemed there were hundreds of them. These days this so called 'particle zoo' has been reduced to twelve: three families of four basic particles (regular matter being made only of the first family—the electron and its neutrino and the 'up' and the 'down' quarks that make up protons and neutrons) But why three families (especially as just one seems sufficient)? Why four particles in each family?

Then there are the forces. There is the super powerful 'strong force' that holds the atomic nucleus together, the powerful 'electro-magnetic' force that holds atoms and molecules together, the rather wimpy 'weak force' that causes radioactivity and the incredibly wimpy force of gravity (if you think I exaggerate, brush your hair and let the comb pick up a piece of paper to witness a mild dose of static electricity overcoming the gravitational attraction of the entire massive earth.)

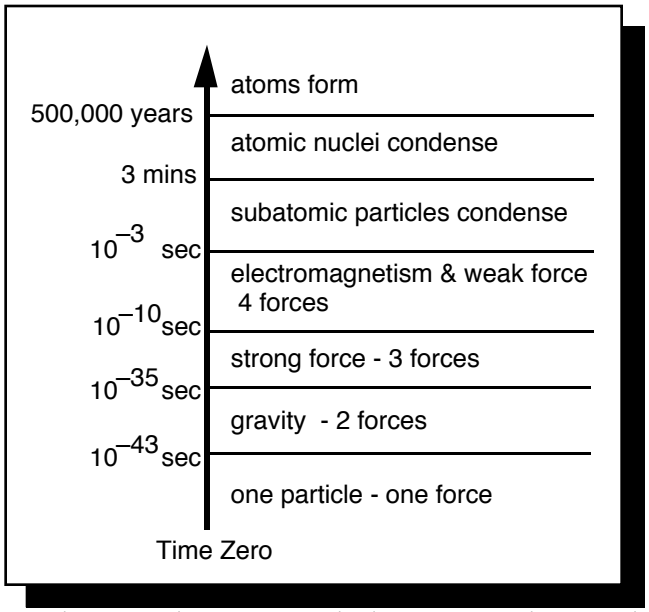
This is what irritates physicists, they are saddled with two theories, twelve particles and four forces when all

they aesthetically want is just one theory, one particle and one force.

From Time Zero

These problems facing physicists also crop up in trying to explain how the universe got going. It is pretty firmly established that our universe started off with a titanic explosion about twenty billion years ago. At that time the universe was a lot simpler, there were no people, animals, plants, planets stars or galaxies—just a thick soup of intensely hot subatomic particles. So to have a good understanding of the Big Bang we have to understand these particles and how they behave.

Scientists call the moment that History began, time zero. Ever since time zero, the universe has been expanding and getting cooler. The closer we get to time zero, the hotter and denser the universe was. Hotter and denser to a physicists means that the particles were closer to each other and were banging into one another with more energy. Just after time zero tiny particles like the electron were banging into each other with the energy of a car crash at 100 mph. That's a lot of energy for a tiny particle.



As might be expected, at these energies things behave a little differently that they do in our relatively sedate universe (the 100 million degree furnace at the center of the sun is freezing cold in comparison.)

One recent advance towards the TOE was the theoretical prediction that, at a high enough temperature, the electromagnetic and weak forces are the same. This 'electro-weak' theory predicted new particles which were eventually discovered which attracted Nobel Prizes for everyone involved. The temperature of the universe cooled to this temperature about one thousandths of a second after time zero. Before this time the two forces we see today were actually just one force.

The next advance towards the TOE was the Grand Unified Theory (GUT) which, in a similar fashion, predicted that, at a much higher temperature yet, the strong nuclear force and the electro-weak force become indistinguishable. In this situation, all the bits of matter (basically electrons and quarks) are interconvertible, they behave as if they were the same particle. The universe cooled below this GUT temperature a billionth billionth billionth of a second after time zero, so before this time there was only one basic particle of matter and two forces—the strong-electro-weak and gravity.

This is where theory comes up against the problematic separation between gravity and the other forces. You might think that understanding what happened a billionth billionth billionth of a second after creation is sufficient, but the curiosity of scientists knows no bounds, they want to get even closer to the Main Event.

Superstring Theory

It seems that the solution and completion of the TOE lies in a recent development called superstring theory.

The reason that superstrings might work where other attempts have failed is because it tackles some very basic assumptions by moving the focus of thought from the material to the immaterial.

From the time of Newton to the beginning of this century, the concepts in physics revolved around the interactions of particles of matter. Nowadays, however, the great discussions in the learned journals are about mathematical concepts. The stuff of the universe appears to be more and more mathematical and less and less material!

Some of the recent advances in this area are contained in the excellent book, Superstrings and the Search for the Theory of Everything, (E. David Peat, Contemporary Books, Chicago.) The author describes how superstring theory challenges a basic assumption held since Newton, that space and time are a smooth and continuous background in which everything occurs—the concept at the basis of the much feared but very useful calculus which is based on the concept of a 'point.'

In math, any line has an infinite number of points along it. You can divide that line into much smaller sections, and each of those sections will still have an infinite number of points along it. In math, you can continue this for as long as you want. This assumption is applied to the fundamental particles which are treated as if they were points.

Superstring theory challenges this assumption and states that there is a minimum length below which you cannot go, which is equivalent to saying that points (and particles) have length. The only reason we have

heretofore been unaware of the grittiness of reality is that the minimum length is very, very small, even on the scale of the tiny atom. This minimum length is about a millionth, billionth, billionth, billionth of an inch.

These little lengths, these bits of space time, are the strings that are supposedly so super.

The space age has made us aware of one of the basic facts of gravity, the closer you get, the stronger it gets. When things are a millionth, billionth, billionth, billionth of an inch apart, it seems that the force of gravity becomes as strong as the other forces.

Particles got further apart than this after about a ten millionth, billionth, billionth, billionth, billionth of a second after time zero. Before this time, however, the superstring TOE seems to predict that there was only one particle and only one force.

So, although there is no scientific reason why the universe couldn't have started off with twelve particles, four forces and two ways of functioning, the belief (because that's what it is) that there was only one of everything in the beginning seems to be gaining support. The final details are not in yet (Winter, 1988), but there's a lot happening in physics.

Once this is sorted out, of course, is the even more challenging question, What was happening even closer to time zero to cause the superparticle and the superforce? One thing is for sure, however, and that is that the physicists abandonment of substantial material will continue and that their answers are going to get even more insubstantial (I dare not say metaphysical for fear of upsetting them) as they move into the realm of pure mathematics. That's one of the advantages of the scientific method, it always gets the right answer eventually.

10. THE POWER OF NOTHING

Contrary to media misconception, the Unification community is remarkably pluralistic. While the Divine Principle itself, of course, is invariable, its role in culture is more like the steel framework of a modern skyscraper than the building itself—while the inner steel girders of the Chrysler and Empire State Buildings are very similar, their 'fleshed-out' forms are so different that they often appear as images of male and female buildings in NYC picture postcards.

To my mind, pluralism is very healthy because it generates a great deal of give-and-take action and this—a girder of the Unification world—is essential for God to work. God does not in a static edifice abide.

With this in mind, you can appreciate how much I enjoyed hearing about a spat at UTS over the nature of God's hyung sang. In Unification Thought, this is sometimes referred to as 'pre-energy'—the aspect of God from which sprang matter and energy. This is in contrast to His Sung Sang from which sprang ideas and laws. Now while I shall probably be doing a great injustice to the subtlety and refinement of the positions being held, on one side of the debate is the declaration that this is rampant dualism—mind and matter being so different that their causes must be as well—while the contraries deny that the Principle concept of God's mind and pre-matter implies that He is not One.

Rather than 'quote the scriptures' as a contribution to this debate, I shall take a look at what modern science has to say about it (what did you expect!)—science is philosophy, after all, it's just philosophy with a conscience, a frame of reference (called experiment) against which it can check itself.

In a nut shell, what science has to say about the cause of matter/energy is "nothing." No, not nothing to say, "nothing" because modern science has found that "nothing" is not as simple as it might appear at first glance.

As an aside: I know of some who declare that "no-God" is a simpler hypothesis than "God" and therefore, by the Occam's-razor preference for minimal assumptions, to be favored. But this assertion is based on the assumption that 'nothing' is simpler than 'something' and, as will (hopefully) be quite clear by the end of this discussion, this is not in accord with current science (though people are, of course, welcome to be 'unscientific' in their beliefs).

Obey the Law

For a start, lets look at the biggest "something" we can conceive of: the entire universe. The stars, the galaxies, the people next-door: This all is a something: Not! as the Waynes of this World might put it. All that matter, all that energy, all that order, our science says, is actually just a form of nothing.

For, against all expectations, the creation of the universe did not disobey the First Law of Thermodynamics: the rule that matter/energy can neither be created nor destroyed.

To understand this we need a little High-school mechanics; the difference between kinetic and potential energy. Consider a cannonball being shot up into the air. As it leaves the cannon it has a lot of (kinetic) energy of movement. As it ascends it slows down and eventually, if only momentarily, it hovers motionless in the air. The energy has not disappeared, of course, it is just in a different form, as the (potential) energy of separation between the ball and the earth. This is rapidly turned back into (kinetic) energy of motion as the ball plunges back to earth.

Potential energy always enters the equations of science as a minus quantity; so one can think of it in terms of as "negative" energy.

Now the (negative) energy of a cannonball a few miles up in the air is large; that of the Moon separated from the Earth by tens of thousands of miles is considerably larger; that of the stars separated from our sun by trillions

of miles is immensely larger yet and that of the galaxies with their billions of suns separated from all the other billions of galaxies by quintillions of miles is…well, let's just call it the negative energy of the universe.

Then take all the matter in the universe—all those suns, galaxies and neighbors, etc.—and, by E=mc2, calculate all the energy—the positive sort, just like kinetic—that is locked up in all the stuff of universe. It's a lot! Call it the positive energy of the universe.

Well, you've probably guessed the punch line: when you add the positive and the negative energy of the universe together you get a big fat zero; a nothing. While the process of creation separated nothing into positive and negative energy, it did not actually create any. Overall, there's still nothing there! This is just a hint that the difference between "something" and "nothing" is a little more subtle than you probably thought.

While we're at it, not only did the creation of the universe not disobey the First, it also did not disobey the Second—the rule that order cannot be created without disorder.

You might have heard that science says that the universe is ordered and is in the process of running down to its 'heat-death'—a concept used socially to support all kinds of pessimistic views. But the concept is now, scientifically at least, quite passé. The reason is that, in just the last few decades, cosmologists have found that every particle of matter (such as an electron) created in the Beginning was accompanied by over 100 billion particles of light (which are experimentally detectable as well as being biblically correct); 300 billion neutrinos (an esoteric form of matter too elusive to be detected with current technology) and an unknown multitude of mysterious particles that have not been seen yet (which is why they are called Dark Matter) but en masse play a key role in the large-scale structure of the universe .

When you do your sums, the amount of order locked up in all the matter as suns, galaxies and neighbors etc. is as nothing compared to all the disorder (technically, the entropy) locked up in all those other particles. The process of creation, it turns out, did not create order; it created a massive amount of disorder and a minuscule amount of order—which is just what the Second Law of Thermodynamics says should happen in any process.

Describing nothing

So what is nothing? Even a common sense view must be approached carefully since so many simple things turn out, when looked at more closely, to be cleverly crafted to look simple but are actually complicated and sophisticated.

A good place to start is deciding just how to describe "nothing" but even this is not so simple. As a UTS professor reminded me when I bounced some of these ideas around his office, there is a Buddhist maxim that "the nothing that can be named is not the nothing." After a moments thought agreed that everyday language, with its fuzzy logic and imprecise concepts, could not pin down the 'real' nothing—but, in riposte, I insisted that the language of mathematics could. And, as we shall see, mathematics has a whole zoo of nothings, some of which are related to the nothings in the world around us.

The simplest concept of nothing is, of course, that of no things: no matter, no light, no neutrinos, no neighbors, etc. etc. The type of nothing is described by the non-threatening equation—

$$1 - 1 = 0$$

—the nothing you get when you have something and then you give it away. This is not a very interesting nothing and, to distinguish it from the others we will encounter, we will refer to it as the trivial nothing.

A much more interesting nothing is the one you get when you take things to extremes—the nothing that is intimately related to its exact complement: infinity. The complementary relation of nothing and infinity is that as you consider larger and larger numbers, their reciprocal becomes smaller and smaller.

$$n \to \infty \text{ then } \frac{1}{n} \to 0 \cong \frac{1}{\infty} = 0$$

In the limit—and if you ever use this equation, make sure you mention that you realize this— as the number gets infinitely big, its reciprocal becomes zero.

The concept of infinity was only pinned down to the general satisfaction of the mathematical community in the late 1800's by Georg Cantor. (A fascinating overview of his work and other aspects of infinity can be found in To Infinity and Beyond by Eli Maor, 1987, Birkhäuser, Boston.) Cantor, much to his surprise it is recorded, discovered that there was a whole series of infinities, each one greater than the one before.

The first infinity is exemplified by the counting numbers. No matter how big a number is, a bigger one can always be obtained by adding a 1 to it. So just how many counting numbers are there? There are an infinity of them and the set of the counting numbers is said to 'denumerate,' as in the first infinity ∞_1 (more commonly symbolized in more advanced works as $\aleph_0$).

Here is our first interesting zero, the one at the end of the infinite series of reciprocals of the counting number.

$$1, 2, 3, 4, 5, 6 \ \ldots \ \infty_1$$

$$\frac{1}{1}, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5} \ \ldots \ \frac{1}{\infty_1} = 0_1$$

Just as the key attribute of the infinity-one is that it is dealing with a set of discrete objects—the counting numbers have gaps (of size 1) between them—the nothing-one inherits this nature and is the discrete nothing we find as we chop objects into smaller and smaller parts.

The vacuum

This mathematical nothing is just like the nothing that quantum physicists have discovered underlies reality. When you remove all the discrete things in nature—such as bodies, cells, atoms, electrons, photons, neutrinos, etc.—you have left what is called the vacuum. This, surely, is a nothing, you might think. Well it is and it isn't —in rather the same way that the universe is a something; but then isn't.

The vacuum, quite unexpectedly, was found to have a strong tendency to form matter-antimatter pairs of particles—such as an electron and a positron—called virtual pairs. The amount of energy involved (exceedingly small) and the time the pair hangs around for (exceedingly brief) never quite amounts to the smallest unit of existence (technically: Plank's Constant) so it doesn't really count as a creation of matter/energy so the First Law is not violated. All the other attributes of the particle pairs, for instance electric charge, come as opposites and cancel out so no charge is actually created (which is another 'no no').

So what science used to think of as the 'empty vacuum' turns out to have a distinctly foamy structure made up of these virtual particles pairs. And, at an even smaller level, it is known that space and time also have a granular structure.

And while a vacuum is a nothing, it is a nothing with a distinctly gritty nature rather reminiscent of the first kind of nothing in mathematics.

Our understanding of what happened during the Big Bang creation of the universe involves the creation of particle-pairs by the vacuum and a very slight asymmetry in their properties which allowed for a small—relatively to all the light that was created—amount of matter to remain when all the rest of the matter-antimatter annihilated. Nothing-one is clearly a powerful kind of nothing.

Power of nothing

But wait, you are probably thinking. What if we took away all the virtual-particle foam and the froth of space time. Would we then have a real nothing? I'm glad you asked that. Yes, there is another level of nothing in nature just as there is in mathematics.

Cantor discovered a larger infinity than the denumerable multitude of the counting numbers. This second infinity is exemplified by the infinity of the decimals or, equivalently, the number of points along a line.

Every decimal number is actually infinitely long—there is no end to the places after the decimal point. A simple fraction, such as a half, is actually 0.5000000… with the … standing for a denumerably-infinite string of zeros. Other simple fractions, such as a third, are 0.333333333… with an infinite string of 3's. Other decimals that cannot be expressed as fractions, such as the ratio p of a circle's perimeter and diameter—have an infinite string of numbers after the decimal point that never fall into a regular pattern 3.1415926535898….

A decimal such as 0,33… (ignoring the decimal point) can be thought of as the concatenation of a set of numbers {3, 33, 333, 3333, 33333, … }. Now this set of numbers is just one of the many possible subsets of the infinity-one of counting numbers. It is very simple to calculate how many subsets there are in a set of size N. As a member of the set can either be in the subset or not, the number of subsets is 2 to the Nth power— 2N — and is called the 'power set' of the set.

Cantor proved that for both finite (easy) and infinite (not so easy) sets, the power set is always larger than the set itself. So the number of decimals—all the possible subsets of the counting numbers concatenated as decimals—is larger than the number of counting numbers and its size is given by

$$2^{\infty_1} = \infty_2$$

This is infinity-two and, unlike the discrete infinity-one, it has no gaps in it—there are no gaps between the points on a line or the decimals—and infinity-two is called the continuum. To misuse the mathematical phrase somewhat, infinity-two is more powerful than infinity-one. This second infinity is also associated, through the reciprocal relationship, with its complement, the second nothing.

$$\frac{1}{\infty_2} = 0_2$$

The 'power' of nothing-two is not the same (greater? lesser?) as that of nothing-one and it has a continuous, rather than a gritty, nature.

False Vacuum

This mathematical nothing-two also has its counterpart in modern science. When you remove the discrete quantum foam of the vacuum and the froth of space-time you are left with what is sometimes called the 'false-vacuum' (and the rest of the time called the "Higgs Field"). This is involved in giving particles mass—without the false vacuum , theories cannot predict the masses of fundamental particles such as the electron and proton. One of the tasks of the Supercollider being built in Texas is to hopefully detect some of the other predicted effects of the false vacuum.

The origin of the universe is also thought to intimately involve the false vacuum. In the very first instant of creation, the universe was much too small to exhibit any granularity in space-time let alone the particle foam of the regular vacuum. The false vacuum, just like nothing-two, had a continuous, rather than a gritty, nature. In this first instant, everything—gravity, electricity, space-time, etc.—was an undifferentiated latency in the false vacuum. It was the collapse of this false vacuum state that drove the inflation of the universe into the stage called the Big Bang—the false vacuum was causal to the Big Bang. The power of nothing-two is quite remarkable—need I say more as to why I gave this column the title "The Power of Nothing".

What next?

The next question is inevitable. What's left when you remove the false vacuum? Surely then we would have a real nothing! Well, to iterate the story, there is another type of nothing in mathematics. The infinity-two of the continuum also has its power set, all the possible subsets of all possible points. As a set of points is usually called a line, a curve or a surface, etc., this infinity-three can be thought of as the infinity of all possible forms.

But this infinity-three also has its power set; the set of all possible combinations of forms or, as we might say, all possible relationships. And this has its power set etc. etc.—a whole infinite hierarchy of infinities each one greater than the next.

And each of these is associated with its own nothing.

$$\infty_1, \infty_2, \infty_3 \ \ldots \ \infty_{\infty_0} \ \ldots ? \ \infty$$
$$0_1, 0_2, 0_3 \ \ldots \ 0_{\infty_0} \ \ldots ? \ 0_\infty$$

Now nobody yet has even the slightest idea which one of these nothings describes—getting back to the debate that prompted this column—the nothing that the Principle calls the Hyung Sang of God, the pre-energy of Unification Thought.

"The nothingness 'before' the creation of the universe is the most complete void that we can imagine—no space, time or matter existed. It is a world without place, without duration or eternity, without number—it is what mathematicians call 'the empty set.' Yet this unthinkable void converts itself into the plennum of existence—a necessary consequence of physical laws. Where are these laws written into that void? What 'tells' the void that it is pregnant with a possible universe? It would seem that even the void is subject to law, a logic that exists prior to space and time." (Heinz R. Pagels Perfect Symmetry: The search for the beginning of time p.347)

But at least one thing is clear, the philosophers do not have to worry that science supports the concept that the cause of matter is at all like matter. Science, as we have seen, says that the cause of matter is very much akin to nothing—nothing to the Nth degree, so to speak—and is akin to the no-thing that characterizes the realm of the mind.

And don't ever let anyone tell you that nothing is simpler than something.

And don't ever underestimate the Power of Nothing!

11. 2, 3 AND 4: DEEP TRUTH OF THE UNIVERSE

It is a difficult time for those who are a little skeptical about the significance of numbers in the way the universe works. Just recently the number three was established by high—energy physicists as fundamental to the way our Universe is constructed. It joins the numbers two and four which have been ensconced for a few years now. The scientific significance of these numbers is that they precisely delimit subatomic particles, the building blocks out of which everything is put together.

Before we get into the heavy detail, just in case you're allergic to science and feel an attack coming on, I'll give you a brief synopsis of the significance of these numbers: two is the number of basic lineages of particles in nature, three is the number of families in one of the lineages, four the number in the other. To a physicist, these families of particles account for everything, the rest is just fancy embroidery. Now for the non-allergic among our readers, some details.

Two Sundered Lineages

One of the great victories of quantum theory was the realization that there are only two basic types of subatomic particles: matter particles that are `bits of stuff' out of which everything is constructed (this lineage is called the `fermions') and exchange particles that these matter particles give and take with each other to interact and make relationships (a lineage called the `gauge vector bosons' or, more familiarly, just bosons for short).

These two lineages both have strange but different statistics, neither does what you would expect `on average.' Bosons clump together more then you would expect. This is like the phenomenon I have often observed in the locker room of my health club. There are 600 lockers there and I usually go when it is quiet. Even if there are only five others there, however, some how we all end clumping together and getting in each other's way. This clumping seems to occur much more than you might expect `on average.' This is boson behavior.

Fermion behavior is just the opposite. Cars commuting into a city without special car pool lanes are almost entirely inhabited by one solitary person, much less togetherness than you might expect. This loner conduct is fermion behavior.

The most recent and sophisticated developments of quantum theory suggest that these two lineages were

actually united at the moment the universe was created but that they irrevocably parted company a trillionth trillionth trillionth of a second later.

These basic lineages give number two its place in the cosmos. Three and four get their position as there are three families of aloof matter particles and four families of chummy exchange particles.

Three Families That Matter.

I found out about the recent enthronement of the number three on the front page of that flaky pillar of the West, The New York Times. It's editors take care that only the most significant news items make it to page one and it is rare that the abstract cogitations of modern physics qualify. So it is probably a sign that there is a place in the history books for the recent announcement on the top, no less, of the front page that a group of American and a group of European scientists had independently proved that there are just three families of matter particles in the universe.

While there is now quite a debate about this, the controversy is not about the accuracy of the discovery, it is the rather mundane one about who can claim the credit for it.

This discovery is as far as science has got in reducing the complexity of the world to it's basic constituents. Just as a million different books are constructed out of some thousands of different words which are constructed out of twenty six different letters which can be made from just a few different strokes of a pen, scientists have been involved for the last few hundred years in figuring out just what our world is made of.

First they found that the myriad of different animals, plants and minerals were constructed out of tens of thousands of different molecules. These are constructed out of just tens of different kinds of atoms. Naturally, the next step was to find out what atoms are made of.

For a while it looked as things were getting more complicated when during the 50's and 60's a whole zoo of subatomic particles were found. It almost took a religious faith during those decades to believe that the universe was constructed in an elegant (read "basically simple") way.

This multiplicity of particles has been resolved by the ideas of super—symmetry (for more information on this see my column "The Search for Beauty in Modern Physics"). This theory revealed that all of familiar matter is made up of just one family of matter particles. This family has four members, two heavyweights (called `up' and `down' quarks, names given during a rather whimsical time in subatomic physics) and two lightweights (the tiny electron and the neutrino that is so anorexic that it seems to have no mass at all).

The electron is the most familiar of these, static electricity being a personal experience of them. The quarks are responsible for the weight of everything and are tightly closeted inside the protons and neutrons that, in different combinations, make up all the different types of atomic nuclei. Electrons and atomic nuclei hook up together to make atoms. The neutrino is the most elusive member of the family, it is so disinterested in relationship that it can sail quite unaffected through a trillion miles of lead. They are all around us, however, as the sun is such a prodigious producer of them that twenty billion or so solar neutrinos speed through your flesh every second (both night and day as the earth is totally transparent as far as they are concerned).

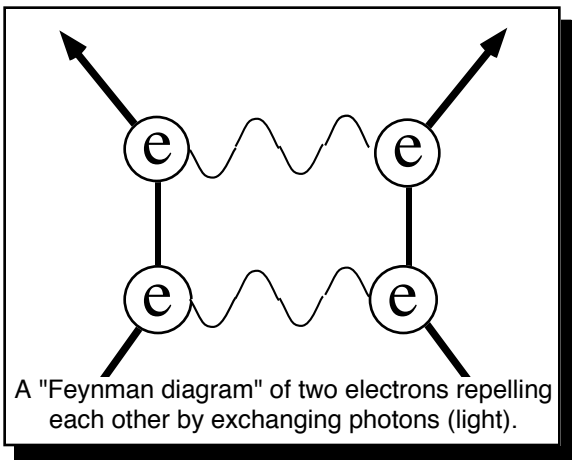
This is the first family, and all the matter in the universe is made of them. There are, however, two more families each with two heavy and two light members. No one is quite sure just what purpose they serve in the universe. As the authors of a recent book, "Particle Physics and Cosmology" noted, "The old question of `who ordered' the muon (the first of the second family to be found), has changed into why are there three families, but it still remains unanswered." There are some tantalizing hints, however, that the two exotic families might have had an important role to play in the very early history of the universe.

Four Gifts for Giving

The significance of the number four derives from the observation that the matter particles are not indifferent to one another, they relate and interact. It turns out that there are only four basic ways that the matter particles can interrelate. These we know as the four forces of nature: electromagnetism, gravity, the strong and the weak nuclear force.

While classical physics (the stuff you still learn in school) had matter and forces as quite distinct things, quantum mechanics revealed that matter and forces are very similar in that they both involve particles. The `forces' we observe between matter particles are actually the result of them exchanging another type or lineage of particles. These interchange particles are called the vector bosons but we can just call them exchange particles.

For example, it was discovered that the interaction of electrically charged particles, like the familiar electron (a fermion) is actually the result of a frenzied interchange of particles of light (bosons called photons), the exchange particles of electromagnetic interaction.



A "Feynman diagram" of two electrons repelling each other by exchanging photons (light).

In human terms, such a frenzied exchange can be likened to the exchange of Christmas cards which is coming upon us soon. Such give and take can maintain a relationship (even if a minimal one) with distant relations, friends and acquaintances over many years. The cards are the bosons, the people are the fermions.

The four basic forces involve four families of exchange particles called photons, gravitons, gluons and intermediate vector bosons. In festive terms, this is like the different types of relationships created by sending a Christmas card, a hand—written letter, a box of toys for the kids, or an announcement that your family is about to descend for a four—week vacation. There is speculation that some `deeper truth' of nature is showing itself in that there are four exchange families and four members in each of the matter families. We have not, by any means reached the bottom of everything yet.

So there you have it, the deep truth of the universe is 2,3 and 4. While these numbers are now scientific dogma of such prestige that they are guaranteed, a starring role in the next generation of physics textbooks, one thing spoils the scientific satisfaction, the actual reason for these particular numbers remaining elusive, inexplicable by even the most speculative of modern theories. This lack can only provide plenty of grist for the numerologist's mill. As I said, it's a bad time for those who are skeptical about the significance of numbers in the way the universe works.

12. Feeble Ploy by Devotees of the Ageless Universe

Modern science agrees with (almost) every religion; there was a starting point to the universe we live in. To be accurate, neither religion or science actually deals with the very moment itself; religion deals with what led up to it, while science deals with what happened just after.

There is a general agreement among religions that an act of will preceded the moment of creation. In Christianity, this involved the commanding Word. While the record shows that the order was obeyed—"And there was light"—it has nothing to say about the moment itself; exactly how the order was carried out.

Similarly, science approaches "time zero," as the start of the Big Bang is called, by working backwards along the cause-and-effect chain it has every reason to trust. A logical sequence of events connects our universe today to one just a quilly-quintillionth of a second just after time zero with every hope of getting to within a zilly-zillionth of a second of the Main Event as science progresses.

For all this, however, there is no hope of getting to the moment itself, even in speculation; Time Zero is a what science calls a "singularity" and, while you can get as close as you want to one, you can never actually get to it. It's a bit like trying to get to zero by dividing by ten—you can get as close to zero as you want, but you'll never actually get there.

Attack

This consensus on the interface between the religious and scientific realms is currently under attack by a group of scientists who, while of little consequence in academic circles, are influencing the larger culture through headlines such as "Scientists Doubt Big Bang Theory of Origins" and the like which have appeared in a variety of publications including *The New York Times* and *The World & I.*

The concepts behind this offensive have been compiled by Eric Lerner in his *The Big Bang Never Happened: A Startling Refutation of the Dominant Theory of the Origin of the Universe* (Random House, 1991).

I had read the article in *The World & I* and thought the fuss unmerited: while the authors had some interesting theories about the role of electric plasmas in the formation of galactic-scale structures they had very little to do with the origin of the universe and that mention was minimally insightful.

But, as it is wise to give a dissent a hearing—at least it can sharpen and focus and, you never know, they might be on to something. So, my bad experience with TW&I article notwithstanding, I went and got the book.

Putting it politely, the book lacks rigor. It is a weed, not a well-cultivated paradigm-changer. But weeds have

a remarkable tendency to propagate unless firmly stomped on, so champions have sallied forth in response to the challenger.

One such rigorous examination of the Big Bang has already appeared in *Nature*, the internationally-acknowledged premier journal of science. While its content is quite technical (appropriately so for the readership, however), "The case for the relativistic hot Big Bang cosmology" (*Nature,* 1991, vol. 352 p. 769-776) by Drs. Peebles, Schramm, Turner and Kron, reviews the concept and its criticisms and concludes that "In the six decades since the formation of the model, advances in observations and experiments have yielded a considerable body of evidence in support of the Big Bang and none that convincingly contradicts it."

A current narrative of the history that connects the Big Bang—time zero—with our universe today—roughly 15 billion years later—can be broken into a series of acts, some of which are better understood than others. The action in each act has left certain relics which are observable today.

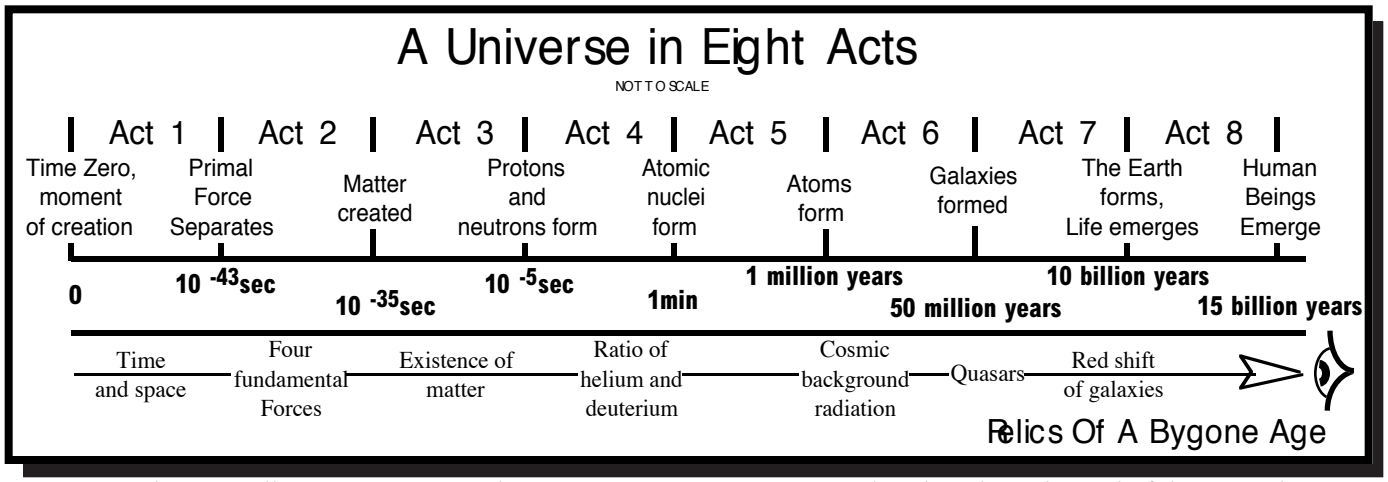
Eight Acts

Act One starts with the actual moment of creation, the Big Bang itself. During this brief act—it only lasts a trillionth, quadrillionth, quadrillionth of a second; that's 43 zeros after the decimal point—things are very simple; just a single unified field that is not force, not matter, not time, not space, but something much simpler. The expectation is that the quantum theory of gravity which is expected "any day now" will reveal what happened during this brief, if significant moment. The relic of this age can be considered to be time and space.

Act Two is not quite so brief—just 35 zeros this time—and the opening number is gravity differentiating out of the unified field. Time-space created in Act One expands and is filled with an extraordinarily dense and hot 'gas' of unified-field-without-gravity pre-subatomic particles.

Act Three begins as the strong nuclear force differentiates out and matter and force become different. This is shortly followed by a final differentiation into electromagnetism and weak nuclear force. This emergence of the four fundamental forces is accessible to theory and experimental testing through high-energy particle physics. It is this differentiation of the forces that is responsible for the creation of matter (see my column "The Creation of Matter" for more detail). The rapid expansion of time-space continues and the universe continues to expand and cool.

Act Four begins when conditions are right for protons and neutrons to coalesce out of the subatomic debris. There is a precise agreement between theoretical expectations and the experimentally measured amounts of these formed. This act ends with the protons and neutrons uniting into subatomic nuclei. Almost all the neutrons formed at the start of Act Four end up in helium with the unattached protons equivalent to the atomic nucleus of hydrogen. Theory accurately predicts that our universe is 90% hydrogen and 10% helium (the other elements so common on the earth and in us human beings were created later by stars and are still a very minor component of the universe as a whole). Theory also predicts that a small number of the neutrons will end up in heavy hydrogen—deuterium—and there is a considerable amount of it in the universe, a fact which is very hard to account for in any other way as the element is not produced by stars—in fact, it is readily consumed by them.



Act Five lasts a million years or so as the universe continues to expand and cool. At the end of this time things are cool enough for electrons and nuclei to get together as atoms. While electrically-charged free electrons readily absorb light, neutral atoms do not. So the hundred-billion or so particles of light that were created along with each particle of matter —"And there was a lot of light"—are now free to wander the universe. While these particles of light started off as powerful X rays and the like, in a sense, the continuing expansion of the universe has stretched them so much that nowadays we see them as weak and faint microwaves. This wash of microwaves is called the 'cosmic background radiation' and is found to be exactly what would be expected from the cooling of a fireball.

Act Six lasted fifty or so million years and is not well understood. During this time the homogeneous gas changes into a lumpy universe of stars, galaxies and clusters of galaxies. The most powerful telescopes can pick

up light that was emitted around this time from quasars, star-sized objects that flame with the energies of billions of suns, and they are thought to be relics of this age. The lack of a clear theory of how all this happened is the rationale the dissenters use to throw doubt on the whole scenario. As the *Nature* article admits:

"Reports of the death of the Big Bang, in popular media and professional journals, often confuse the Big Bang model with free parameters such as ... the large structures observed in the distribution of galaxies ... but this would be a problem for the Big Bang model itself only if it were shown that there was no plausible way to account for these structures within the relativistic expanding world model. [But] there is no shortage of ideas on how it might be done."

While the dissent comes up with some interesting suggestions based on the dynamics of interacting plasma [charged gas], detailed in Lerner 's chapter on "The Plasma Universe," this is a development that can be included in the standard model, and in no way a replacement for it.

Act Seven lasted ten billion years, during which giant stars form; burn hydrogen into an "ash" of carbon, oxygen, iron etc.; and, during their death throes, scatter these elements—as well as creating some interesting ones such as gold—to be gathered up in the formation of the next generation of stars. The galaxies continue to move apart as time-space continues its expansion, and this can be seen to this day in the "Red Shift" of the light we can pick up from distant galaxies. From our point-of-view, it seems as if the whole universe is fleeing away from us, the further away they are, the faster they flee. This is not because the earth is so dreadful, rather it is the very fabric of space-time expanding, dragging the galaxies apart. Logic implies that if the galaxies are flying apart, some time back they must have been close together.

The curtain rose on Act Eight—which marks the end of the First Day in the Biblical chronicle—with the creation of our dear old earth during the formation of our sun about five billion years ago. Just a few hundred million years later there occurred a extraordinary event that, as far as we know, has occurred only on the earth—the emergence of life (so soon, however, after the formation of the earth as to suggest that we might confidently expect to find at least simple bacterial life on other earth-like planets.)

For most of Act Eight it was a bacterial world, but things got perking towards the end and eventually, just hundreds of thousands of years ago, what was actually an Eight-Act Overture ended and the actual drama began with the emergence of self-aware human beings, a dramatic 'moment' we are still participating in.

Motivation

This scenario has a great deal of detail left to fill in; the condensation of galactic-scale systems being but one of them. Be that as it may, a great deal has been pieced together into a coherent whole: the four forces, the creation of matter, the ratio of hydrogen/helium, the abundance of deuterium, the cosmic background glow, the quasars, the red-shifted fleeing of the galaxies.

Mr. Lerner and his confederates make a valiant attempt to cobble together an alternative explanation—usually with theoretically unlikely assertions such as "the cosmic rays colliding with the background plasma *will* generate [deuterium]" or remarkably contrived situations such as a whole generation of massive stars that just big enough to burn hydrogen to helium, sloughing it off so that the cosmic abundance gets up to 25%, but not big enough to create oxygen and carbon keeping the abundance below the 0.1% observed. And so on it tiresomely, and most unconvincingly, goes. I had to drag my unwilling self through it all.

One has to wonder, why are they doing it? Why are they going through such far-fetched contortions to discredit a theory that continues to amaze with its power to combine disparate discoveries in particle physics and astronomy into a seamless whole?

They inadvertently answer this question themselves.

One of the neatest tricks in a debate is to neutralize an opponent's accusation by turning it on them first—by falsely accusing them of doing what you are doing. The Introduction in Learner's book does just that: "The Big Bang and 20th century cosmology constitutes a startling return to discredited medieval concepts .... It is from these primarily philosophical premises, rather than observation, that present-day cosmology developed." p.7

Putting it less politely, this is a cartload of composted organic material recently emerged from the nether end of a bull.

The concept of the Big Bang was forced by the weight of experimental evidence on a science that was quite comfortable with a steady-state universe—one that had no beginning or no end. The Newtonian universe of mechanical delight, on the other hand, had no beginning —which probably suited those who felt that the proper role of science was to dispel the myths and superstition of religion.

Perhaps, then, it is the authors of the dissent who want to return to the comfort of an ageless universe; they are the ones with a philosophical/theological purpose. As they state at the start: "Such observations are far more consistent with new theories based on the idea that the universe has existed for an infinite time—without beginning or end" p. 4 which is Aristotelian philosophy.

Could it be that there is a certain type of person who is uncomfortable with the idea that science and religion can agree on something? And, even worse, that they can both be right?

13. THE EXPANDING UNIVERSE AND THE WORLD OF SPIRIT

One of the biggest problems facing a scientist who is interested in 'spiritual things' is that most of the phenomena are of a personal nature and not accessible for study. There might be one area, however, that is accessible to the scientific method of study where the realms of matter and spirit touch upon each other. This possibility is opened up by the discovery that our universe is not static, it is expanding.

The Red Shift

The concept of an expanding universe is based on an observation of what is known as the "red shift." The most everyday-type example of this (in fact the only one I've ever seen used) is the sound of a train whistle.

As the train steams (well, the old ones used to) towards you the sound waves are 'compressed' into the declining space between you both, and this raises the frequency of the sound you hear. So if the whistle was tuned to middle C and you had perfect pitch, you would notice that the note was sharp.

Conversely, as the train chugged away from you the waves would be 'stretched' by the increasing space between you and you would hear that the note was now flat.

Light has a wavelike character and it behaves in the same way. Red light has a (relatively) long wavelength (a 'low' note) and blue light a short wavelength (a 'high' note).

If a body emitting light is moving towards us (and it has to be moving very fast to be at all noticeable) the light appears 'sharp' or shifted towards the blue. If the body is moving away the light is 'flat' or shifted towards the red.

But in order to notice the shift there must be set 'notes'—the equivalent of middle C. Well it just so happens (what a nonsense phrase for a theistic article, replace that with 'It was planned that') there are also set 'notes' in the light emitted by stars.

If you've ever sprinkled salt in a gas flame while delicately seasoning a hamburger you might have noticed the brilliant yellow light that flares up. This is one of the pure 'tones'—of precise wavelength—of light emitted by sodium when heated. Each element has its own distinct set of wavelengths called the 'emission spectra'.

When the light arriving from a distant star is spread apart by a prism into a spectrum, these emission spectra can be recognized for many different elements.

Cosmic contagion

Now we get to the point. When the light from the very distant galaxies is examined, all the wavelengths in the emission spectra are shifted towards the red. Hopefully, the phrase 'red shift' now has some meaning.

Although there are some esoteric interpretations of this fact, the simplest, and generally accepted, interpretation is that all the other galaxies are speeding away from us.

Another very significant fact that is revealed by further study of these red shifts, is that the further away a galaxy is from us, the faster it is running away from us.

It is as if the earth had a nasty disease and everyone wanted to get away as fast as they could.

This curious fact, first discovered by a Dr. Hubble, is such that a nice straight line can be drawn plotting distance away from us against how fast it is speeding away (measured by the red shift). The mathematical relationship between 'red shift' and 'distance away' is called the 'Hubble constant.' It is very useful for astronomers who only need to measure the red shift of an unknown galaxy to calculate just how far away it is.

As soon as scientists began to digest this new information, it became clear that there were two very startling conclusions they couldn't help coming to:

— This expansion must have started somewhere and,

— we seem at first glance (after all that fuss about the earth not being at the center of everything was sorted out just a few centuries back) to be smack right at the center of the whole expanding universe.

The Big Bang

If you run time backwards from today, the universe will contract. As you go back the galaxies get closer to each other. Keep going long enough and they are all together. As you can't get closer than that this must be the beginning of the expansion that we still see today. Estimates puts this 'time zero' between 15 and 20 billion (20,000,000,000) years ago.

Now the closer you squeeze things together the hotter they get, so back at time zero it must have been very hot, way up in the zillions of degrees. So hot in fact that matter couldn't exist at all. The energy was in the form of pure radiation (like light).

So it is easy to see why the name "Big Bang" was invented and stuck and how the revelation recorded in Genesis 3:3 hit the nail on the head with "And God said 'Let there be light;' and there was light."

This original radiation has cooled nowadays, but it is still there as the background micro-wave radiation that radio-astronomers can listen to—the whisper echo of the act of creation. Who would have though that radio-astronomy could be so religiously awe-inspiring!

At the center

Back to the other aspect of the expanding universe—the fact that we seem to be at the center and everything else is moving away from us.

It only seems that the universe is earth-centered. The strange fact is that, if you were able to observe the universe from any other galaxy, you also seem to be at the center—all the other galaxies would be flying away from you, and the further away, the faster they'd be flying.

At first glance this does not seem to make sense, how can every place be at the center?

The mathematics that describe this curious situation introduce the idea of higher spatial dimensions. Although everyone has heard that 'time is the fourth dimension,' it is quite obvious that time is different to the three spatial dimensions of length, breadth and height. Going up and down is simple, going back in time is not. The expansion of the universe introduces a fourth spatial dimension which has its equivalent of up and down. We, however, cannot move in this dimension because we don't exist in it, or, to be more mathematically precise about it, we have no 'extension' in that dimension.

To get a feel for the mathematics that describe these higher spatial dimensions we need an analogy.

Two dimensional man

There is a delightful book called "Flatland" written by Edwin A. Abbott in the nineteenth century. It recounts the experience of a person living in a two-dimensional reality who encounters a three-dimensional person.

In Flatland everything has length and width but there is no depth. (Perhaps you know a few of these people?) Mathematically speaking, their world has no extension in the third spatial dimension.

A similar world has been developed in a more recent book "The Planiverse" by A. K. Dewdney. He fully develops a compelling two-dimensional reality that is explored through a friendship that develops via a computer hookup between the author and an inhabitant of the 2-D world. The author was inspired to write the book by the very idea we have been discussing. "I was reading a popular work on cosmology," Dr. Dewdney, a professor of computer science acknowledges, "and came across the familiar analogy which describes the expansion of our own three-dimensional universe in terms of a balloon whose two-dimensional skin continually expands."

The only difference between Flatland and the Planiverse is the missing dimension—Flatland has no up and down while the Planiverse has no left and right. The problems the inhabitants face because of their two-dimensionality, however, are very similar.

The Balloon

Now imagine that you are a Flatlander astronomer. You discover, rather as our three-dimensional ones have, that the distant parts of Flatland are moving away from you and that the further away they are the faster they are moving. And it's the same wherever in Flatland you do the measuring from.

Eventually you work out the mathematics—the two-dimensional reality of Flatland is expanding in a third, spatial dimension. He calculates that this expansion must have had a beginning, but the point of origin where the expansion began is not in Flatland, it is in the unknown third dimension.

Although this is something that can be mathematically sensible, it can never really make sense to Flatlanders who cannot experience this third dimension. To us privileged three-dimensioners, however, it is simple to see that Flatland is actually the surface of a balloon that is being blown up. The point of origin of the expansion is not on the surface of the balloon, it is at the center, a place that is inaccessible to the Flatlanders.

The Fifth Dimension

This is exactly analogous to our own situation. The equations that describe the expanding universe say that our four-dimensional space-time is expanding in a fifth spatial dimension. The origin of our universe—the 'point' at which the Big Bang occurred—is not within our universe at all, it is in that higher dimension.

At last I get to my point (which, incidentally, has no dimensions). What is this higher dimension that appears in the scientific equations. It is as real as the others, we are just not equipped physically to experience it. Well, it's speculation, but to my mind this higher dimension can be none other than one of the dimensions of the spirit world.

Intra-dimensional contact

Back to Flatland while you chew on that one. What would a Flatlander experience in an encounter with a three-dimensional being. As Mr. Abbott so cleverly surmises, you would appear to them as almost magical. You could appear at any point in their universe at will, seemingly be everywhere—and sometimes nowhere—at once, you can see them while they cannot see you, you can move through locked doors and appear in the midst of them at will, etc. etc.

Is this not a little like an encounter with a spiritual being? Not having been inundated with visitors myself, I can only go by accounts of other's experiences. They do seem remarkably similar.

As Mr. Abbott dedicates his book:

"This work is dedicated by a humble native of Flatland in the hope that, even as he was initiated into the

mysteries of Three Dimensions, having been previously conversant with only two, so the citizens of that Celestial Region may aspire yet higher and higher..."

14. WHO SAID, "EVERYTHING IS RELATIVE"?

I am sure that almost anyone reading the title will invoke that towering genius of scientific authority: 'Einstein!' (If not, the picture should help.) Everyone knows it's an historical fact, Einstein proved that 'Everything Is Relative.' Isn't that right?

No it's not! His most significant contribution to science was actually a concept that is almost exactly opposite of 'everything's relative.' Which is extraordinarily strange, considering how the concept "it's all relative" he supposedly proved has influenced the non-scientific world.

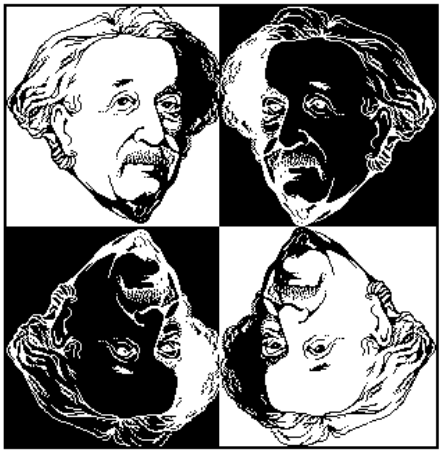
I was at an Arts Conference as a journalist last year when I had my chance to make a stand for 'What He Really Said.' Unfortunately, I blew it.

A speaker had been talking about 'Absolute Values in the Arts' and the rather sophisticated audience (it was the Waldorf Astoria, after all) was warming up to his ideas. Then, like a breeze from the Arctic, one of the participants pointed out that, while what the speaker had said was all very nice and idealistic, it had already been proven Scientifically beyond any Possibility of Doubt that Everything is Relative. (He was the sort of actor who can speak in such a way that you actually hear the Capital Letters.)

Realizing that this was my chance to set the record straight, I thought carefully about how I could explain (to a very non-technical bunch) what Einstein had really proved. It took a while, but I figured it all out and was about to raise my hand to speak when I realized that my moment had passed me by, they were now avidly discussing the problems of financing an orchestra and, not being a celebrity (like almost everyone else), I dared not interrupt to change the subject back again.

So my thoughts that day on Everything is Not Relative have had to wait till now.

The principle that Einstein actually used in the development of his earthshaking insights was not that everything is relative but that important things don't change, they are invariant.



The foundation of the Theory of Relativity (his first, or "Special" one) is that one of the fundamental quantities in physics, the speed of light, is always the same no matter who measures it, and, most importantly, no matter at what speed they are moving. This is not so intuitive (which is why Einstein is considered a genius). Stand on the ground and measure the speed of a Concorde passing overhead, say it's 1000 mph. Now get in a Boeing 747 moving in the same direction at 600 mph. As Concorde passes you measure its speed. As you might expect, the Concorde only seems to be traveling at 400 mph. There seems nothing odd about this.

Do the same thing with light, however, and something unexpected happens. Stand on the ground and measure the speed of a beam of light passing you, it's about 670,000,000 mph. Get in a rocket moving at 100,000,000 mph (in the same direction) and measure the speed of the light again, it's still 670,000,000 mph. Speed up the rocket and try again at 500,000,000 mph, the beam of light will still pass you at 670,000,000 mph.

The speed you are moving at is irrelevant, your 'frame of reference' is just as good as anybody else's (this is where the 'it's all relative' idea came from). No matter what your frame of reference is, the laws of physics never change. This is very convenient because the Earth zips through space at quite a pace and it would be most inconvenient if all our scientific laws were only true for this speed and were different at other speeds. So Einstein gave a firm theoretical foundation for what everyone was doing anyway, ignoring the fact that the earth is zipping through space at great speed.

But 'everything's relative' is not the lesson here, the real message is that the important things about our universe never change, so Einstein actually showed that there are absolute truths that invariably apply. I imagine he's probably kicking himself Up There Somewhere—can you imagine what a difference it would have made to our culture if he had called it the Theory of Invariance and, ever after, people went around insisting that, "Everything is Invariant."

A Global Change

This key concept of invariance introduced by Einstein is the foundation of the most powerful concepts in modern subatomic physics, the 'gauge theories' that are all the rage these days. (They are called gauge theories because they involve measuring.)

Einstein's work with light is an example of a gauge theory. When two experimenters choose different

reference points for their experiments they naturally end up with different sets of measurements. (If you assume the earth is at rest you will have one set of measurements, if you assume the sun is at rest you are going to have a very different set of measurements.) Einstein basically proved, however , that the differences always cancel out and that the calculated laws of physics (in his case, the speed of light) always turns out the same. So you can boil all of Einstein's work down to the fact that the laws of physics are invariant under translation (no, not from Korean, 'translation' is just the fancy scientific word for movement.)

This theory is an example of a global type of invariance, you convert measurements in one frame of reference into another with a global factor. An everyday example of this is two Manhattan City Planners (I know such people don't exist, but this is a "Let's Pretend," what scientists, a little more formally call a 'Thought Experiment'). One of them measures everything from the Empire State Building and gets one set of measurements. The other uses Madison Square Garden as his zero point. Although the locations of the buildings on which they are doing their planning look very different, they can communicate with each other. (I know this is stretching your capacity for 'let's pretend' to the limit, but please persevere.) It is easy to convert the first set of measurements into the second with the global factor 'add three blocks west.'

Einstein's theory involved movement in your ordinary, everyday type of space. These days the 'spaces' in which particle physicists test for invariance seem to be very abstract, yet almost all the great discoveries in subatomic physics these days assume that these abstract spaces are very real.

One of the more familiar of these abstract spaces involves electric charge. The best description of charge involves something like a top spinning around, but not spinning in your ordinary, everyday type of space but in the more abstract (or higher dimension) of 'charge space.' A spin up is positive, a spin down is negative.

There is a global invariance in this charge space. Suppose a super powerful, omnipotent wizard one day, out of ennui decided to simultaneously turn all the negative charges in the universe into positive ones and all the positive ones into negative ones. The excitement he might have expected from the ensuing chaos would not materialize, however, as no one would notice. The universe would continue on its merry way as if nothing whatsoever had happened. A physics advisor to the wizard could have foretold his disappointment knowing that electric charge is globally invariant.

Subatomic Bicycles

While global invariance is powerful in predicting the ways the universe behaves, even more powerful is the local variety. In the global variety there is still a sense that certain points, like the reference, are special. Scientists, however, would feel a lot more comfortable if every location was the same—a little like every single person in Manhattan deciding that they are the center of everything (a quite accurate description, actually) and that they were the zero point from which everything should be measured.

Scientists now ask how the laws of physics can be invariant under this situation of local invariance. Clearly a single global factor is no longer sufficient to transform one set of measurements into another. When the math was worked out (and believe me, it is not easy math) it insisted that there had to be 'messenger particles' (or wave disturbances which at the microscopic level are the same thing) connecting everything together. This is the subatomic equivalent of the swarms of lethal bicycle messengers that are needed to constantly ferry information around Manhattan in order to keep the city working (believe me, if they weren't an absolute necessity they would be banned instantly as there is not a person here who has not glimpsed death under their wheels).

The remarkable thing is that this rather subtle math accurately describes the way the way the universe seems to work.

For instance, applied to electric charge, local invariance insists that there be a particle/wave that connects charges. This turns out to be what we call light (in the scientific sense that also embraces radio, micro, infra-red, ultra-violet, X and gamma rays). Thus the principle of local invariance actually requires light to exist, quite a triumph for theory (as light clearly does exist.) Another example of what Eugene Wigner, Nobel Laureate and recipient of the ICUS Founder's Award, called "the unreasonable effectiveness of mathematics in the natural sciences."

This could be considered as undercutting religious teaching as, instead of God saying "Let there be light," all He really needed to say was "Let there be local invariance." But this is really a point for the theologians to debate.

Nobel Prizes All Round

Just recently, a whole clutch of Nobel Prizes were awarded for another advance based on invariance. The accomplishment was the unification of two of the four fundamental forces of nature, the Weak Nuclear Force and that of Electromagnetism.

This is worthy of the Nobel because, on the surface, these two forces seem to be so very different. Look up into the night sky and, seeing a star, you are being influenced by electromagnetism over distances measured in the billions and trillions of miles. And that light ray has existed patiently for millions of years as it zipped towards its rendezvous with your eye.

On the other hand, the reason why until recently no one had noticed the weak force is because its influence can only be felt over such tiny distances as to make even an atom seem immense in comparison. And the duration of its effect is transient in the extreme, coming and going in only a trillionth, trillionth of a second. And it isn't

called the weak force for nothing having only one hundred thousandth the strength of electromagnetism (though, to be fair, it is still robust compared to gravity which is ridiculously ineffectual at the atomic level.)

It is only on the surface, however, that these two forces are different. The principle of local invariance showed how these two forces were basically the same force with two expressions, one involving light as the gauge particle and the other some oddities called W and Z Bosons which nobody had ever seen before. Before long, however, the hunt was on and they were eventually found by a team of European scientist. Nobel prizes all round!

So you see it is the Principle of Invariance introduced by Einstein that is the powerful and significant force in physics.

So if you're ever with a bunch a famous artists and someone tries to make a point based on 'Everything is Relative,' don't wait to set them straight, tell them about invariance and the search for the W Boson. If you explain it well enough, perhaps one day 'Everything is Invariant' will become a cliché.

15. MODERN SCIENCE LINKS SPACE, TIME AND MIND

Do you recall reading this: What is the destiny of science? Until now, scientific research has not embraced the internal world of cause, but only the external world of result; not the world of essence, but only the world of phenomena. Today science is entering a higher dimension; it is no longer concerned exclusively with the external world of result and phenomena, but has begun to examine the internal world of cause and essence as well. (*Divine Principle*, 5th ed., 1977. p. 18)

One day, I am confident, this will be recognized as a prophecy of the first rank. You see, the remarkable thing is, that while the work of figuring out the foundations of modern physics was completed as Quantum Mechanics by the fifties, its meaning was buried in a multitude of detail and the esoterica of matrix mechanics and complex vector-spaces. It is only now, decades later, that the real import of quantum mechanics is beginning to emerge—yet the Introduction to the Principle confidently asserted that science was already examining "the internal world of cause and essence" long before the scientists realized what they were doing.

What is only now emerging is that the conceptual framework developed by the quantum physicists, put simply, links the external world of space and time with the internal world of mind.

As is always true, such a development has not occurred in a vacuum, it is based on the work of many over a period of many years.

In fact. a good case can be made that the story starts thousands of years ago in the mud of the annual flood of the Nile. The dilemma this imposed on the Ancient Egyptians was how to figure out whose bit-of-land was whose, after the waters had subsided leaving everything covered with a layer of concealing ooze.

Space

Fighting was the solution at first, but eventually the priestly class came up with a much better way using large triangles measured from fixed features such as a pyramid or mountain. They found particularly useful a remarkable triangle with sides in the ratio of 3, 4 and 5 which always contained a perfect right angle which was helpful in giving everyone their fair-squares of land back after the flood.

The next step along from this modest beginning happened just across the Mediterranean in Greece where, just about twenty five hundred years ago, an inquiring mind became socially acceptable and the Egyptian observation was explained by a philosopher from the island of Samos.

Using pure logic, he found that the 3-4-5 triangle was just one of an infinite number of different triangles, all described by the theorem that has engraved the name "Pythagoras" into the minds of countless school children down the millennia:

In any right-angle triangle, the square of the side opposite the right angle is equal to the sum of the squares of the other two sides.

This is what mathematicians generalize as the relationship between the size of an object, s, and its projections as height, width and breadth; x, y and z. This relationship is simply expressed algebraically (a convenience not available to Pythagoras, of course) as $s^2 = x^2 + y^2 + z^2$.

Now, while the size of a 2-by-4 piece of wood, say, does not change just because you twirl it around; the rotation alters its projection from being a tall and narrow post to that of a short and wide beam. Our brain is wired in such a way that a baby knows all about this, at least intuitively, by the time they are a year old—they know its the same object no matter what angle they look at it from.

In a somewhat grandiose manner, science states that size remains "invariant" under the operation of rotation.

The simple Pythagorean relationship was clearly significant—which is why it was passed down to us through the dark ages—but no one thought to say *why* it was so significant until, almost 2000 years later, when in renaissance France, Descartes, one of the philosophical founders of our modern age, decided that spatial extension must be what distinguished matter from mind.

The things of the mind realm—the *Res Cogitans* as he called them—were characterized by what they *didn't* have —and what they didn't have was spatial extension. In a nutshell, they didn't have size, they didn't follow the Pythagorean relationship. On the other hand, he said, things in the matter realm did.

The historical consequence of this separation of mind from body—Cartesian Dualism, as his explanation came to be called—was spectacular, to say the least.

You see, before Descartes, people, such as Aristotle had mind-things and matter-things all mixed up. The tree falls because of its desire to go to the earth, was how Aristotle explained things, and he must have made a lot of sense because no one disagreed with him for over two thousand years and Descartes' freeing matter-stuff to be examined without reference to mind-stuff.

Within a century, Sir Isaac Newton had abolished the barrier between the heavens and the earth. He found that with his description of gravity he could explain how the apple fell from the tree as well as what moved the moon and the planets through the heavens.

In a moment of quite uncharacteristic modesty he acknowledged those, such as Decorates, who had opened the way by declaring that, "If I have seen further, it is by standing on the shoulders of giants."

This development is considered to mark the birth of our science.

After Newton, matter was described in terms of its external, spatial extension; bits of matter were considered to be like little pool balls bouncing around. On Newton's foundation was constructed the rest of science—a structure now called classical science—and this is the science you learnt in school and probably what you think is the "scientific" view of the world.

If you <u>do</u> think that, you'd be wrong. Cause science has moved on.

Space and Time

It took another genius to substantial enlarge the foundation created by Newton.

Einstein, just this century, found that it was not really the spatial extension that was invariant, but rather the extension in time-and-space that was the real invariant.

He found that something as simple as a lighted match, with a length of two inches and a duration of one minute, would look very different if you were moving very, very quickly past it—it would be one inch long but last for two minutes.

It is the same match and its objective reality, which he called its worldline, w, is related to the spatial and temporal extensions s and t in a simple extension of the Pythagorean relationship: $w^2 = s^2 + t^2$.

The worldline is the invariant but, just as the width and height of an object seem to change with rotation, the spatial and temporal extensions seem to change with linear motion. Or, putting it another way, the worldline is invariant under the operation of linear motion. The only reason we don't usually notice this is because we habitually travel around at speeds significantly slower than that of light.

Einstein later told a friend that he was horrified by the "everything's relative" social misuse of his work and wished that he'd used the much more accurate "Principle of Invariance" instead.

"Everything's invariant, man!"

This change in perspective continued stimulated by the highly sophisticated development of the impulse of every child to pull things apart to see what they are made of.

It was found that when such smashing was taken to the extreme, everything turned out to be made up of various combinations of just two so-called fundamental particles—the electron and the quark. And, as quarks live a convent-like confined life in the atomic nucleus and play little part in everyday life, almost everything could be understood if we understand the electron.

So scientists took a close look at the electron.

They fully expected the electron, of course, to behave just the way things *made* of electrons behave—basically they expected electrons to conduct themselves just like tiny pool balls.

It seems obvious, but the important thing about pool balls, to both the pool shark and the scientist, is that you know where they are when you start and you can know, through either the laws of mechanics or shooting a lot of pool, just where the balls are going to end up.

Scientists, therefore, expected that they would be able to pinpoint the electron and that, once they had figured out the appropriate laws, they would be able to predict what the electrons would do.

So you can imagine their surprise when it turned out that the electron doesn't play pool at all, rather it plays the subatomic equivalent of roulette.

It turned out that was impossible, in principle, to know where an electron is and where it is going with certainty. Just like roulette, all you can know about the electron is the probability of finding it in a particular state.

Such behavior is not-at-all common sense—but, when common sense conflicted with probability, probability won every time. In some set ups, for example, the electron might sometimes be found at one spot and sometimes at another—but never anywhere in between. This "tunneling", as it is called, occurs because the electron has a probability of being in one place and the other—but no probability of being anywhere in between.

The only reason, it turns out, why things made of electrons—such as you and me—don't teleport with ease—long a possibility in the creative imaginations of science fiction writers—is that this tendency cancels out and things tend, instead, to stay in the same place.

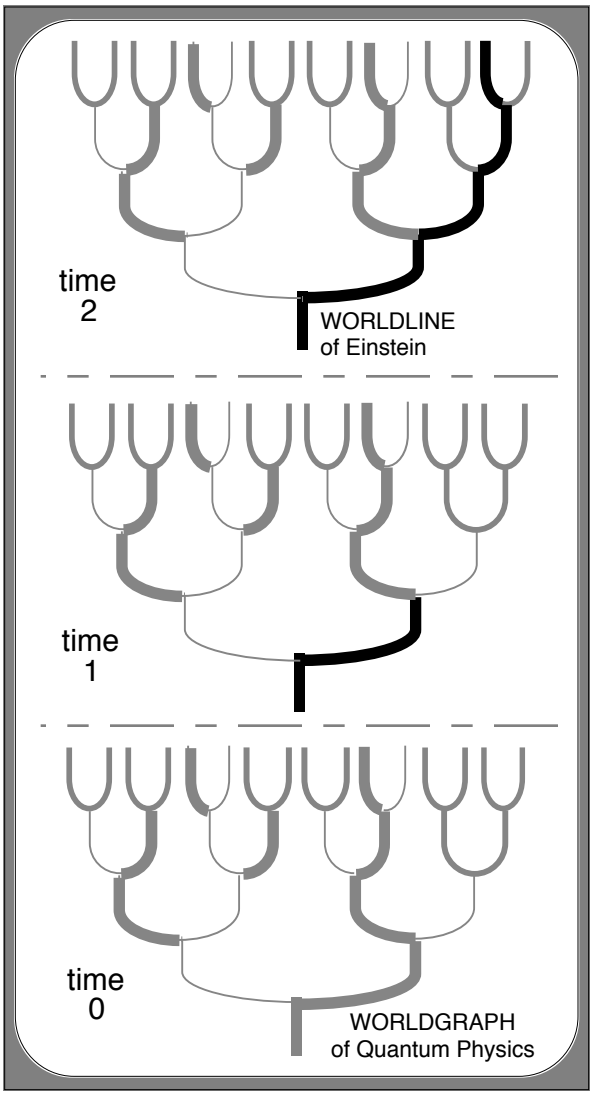
Space, Time and Mind

The explanation for such non-pool ball behavior, it turned out, does not involve the time-and-space extension of the electron, rather, it involved an aspect of the electron that had never been noticed in matter before, an extension that physicists called the wavefunction—usually labeled with the Greek letter psi, ψ ("sigh")—and its projection as psi-squared, ψ^2.

In non-technical terms, psi can be thought of as a measure of the *tendency* to follow a particular history.

It turned out that the worldline of Einstein only dealt with the past of an object—where it was and what it did—while the future history was a combination of this worldline extension and the psi extension.

When there is a choice of future paths, all the factors involved—which, for a simple system such as an electron, are described by the 'action equation' of the electron—combine to create the psi extension—which you will not go very-far-wrong in thinking of as an arrow: big psi, big arrow; little psi, little arrow.



The key insight in the development of quantum physics was the realization that the probability of a particular history being followed was simply psi-squared, that the probability of following a particular path was just the projection of the tendency, the probability was psi-squared, Ψ^2.

So the invariant is not the worldline, rather it is something we can call the world graph of an object.

In the illustration, at time zero the future opens up with all its possibilities each of which has its associated probability (indicated by the width of the gray line. This graph-in-gray is an extension in time-and-space but is a potential extension, not an actual one. A little later, time 1, one of these paths was followed, a probable one here, and the worldline is now an actual extension in space-time. A little later still, the worldline has progressed further still, at one point following a less-probable path which occasionally happens. You will see, however, that the world net is unchanged, all the other ramifications becoming might-have-beens.

The connection between the worldgraph, symbolized by the Greek letter Ω, and the time, space and psi extensions is just the Pythagorean one again: $\Omega^2 = s^2 + t^2 + \psi^2$. Succinctly, quantum physics has that the worldgraph of an object is invariant under the operation of movement through time. That, believe it or not, is the simple essence of quantum physics though you'll probably need to go to graduate school to fill in all the details.

So, to summarize, the size of an object is invariant under the operation of rotation; the worldline of an object is invariant under the operation of linear motion; and the worldgraph of an object is invariant under the operation of movement through time.

It is the worldgraph that is the real object of scientific study, it is this that is created by the natural laws. It is the worldgraph that underlies all phenomena. What *actually* happens is history, what particular branch of the graph was followed. While modern physics has an excellent understanding of both aspects—the principles that govern the psi extension of particles (expressed as the action equation, remember) as well as the actual history, their creation in the Big Bang—modern biology is almost wholly constrained to the historical description of what actually happened and has little understanding of the underlying principles.

It is this worldgraph that theologians are speaking of when they say that, "God Knows Everything!" It is the worldline that theologians are speaking of when they say that the universe is autonomous, it runs without God tinkering to keep it moving. Most theologians agree that, while God knows what you can do, He does not know what you will do. Quantum mechanics makes this apply to everything: while God knows what path an electron can follow, and the probability of each path; He does not know which path the electron will follow.

Mind?

Now I am sure there is least one question left unanswered—if the psi extension of the wavefunction is not pointing in the spatial dimensions, and its not pointing in the temporal dimension, then just where is it pointing?

Our current level of scientific understanding answers this question—but only in a fashion—with the explanation that the wavefunction extension is internal, it is pointing not in an external dimension, such as space and time, but in an internal dimension.

Well, you might ask at little exasperatedly, just what is an internal dimension, where is this internal space? Ahh, the scientist will answer with a wry shake of the head, we don't know the answer to that question, but then we don't know what the external dimensions of time and space are either!

Now I have a confession to make. I have sort of hinted that modern science explains the mind. Well, that is a bit of a come on since science does not understand the human mind at all, it does not even have a handle on the mind of plants and animals—or even cells for that matter.

But the internal extension of the electron, the psi-wavefunction aspect, is what a non-scientist might call the mind of the electron, the invisible, intangible, internal aspect that determines its future, its inherent directive nature.

And what electrons have we can confidently expect things made of electrons to have as well.

Classical physics (which includes Einstein's worldline) was puzzled by the "arrow of time" as all the laws of nature were thought to work on the external extension and be reversible in time. There were, to be sure, the thermodynamic arrow (things get disordered—technically entropy increases—and broken crockery doesn't spontaneously reassemble), the cosmological arrow (the universe is expanding) and the physiological arrow (we remember the past but not the future)—but how were these different arrows connected to each other? It seemed unreasonable to think that they were unconnected and all just happened to be pointing in the same direction.

The new physics reveals the underlying connection between the time arrows: the tendency of things to be in the most probable states (the disordered, unfortunately) is directly related to the psi extension of things; the tendency of the universe to expand (at the start when it was most crucial) can be calculated and was highly probable; and memory involves the worldline not the worldgraph. The arrows of time are all connected to the psi extension and its expression as the worldline.

One thing emerges, though, Descartes got it wrong—the difference between mind and body is *not* that matter has extension while mind does not—the difference is actually that of an extension in an internal space and an extension in an external space.

There you have it, as predicted, the way that modern science "is no longer concerned exclusively with the external world of result and phenomena, but has begun to examine the internal world of cause and essence as well."

16. And You Wondered Why Your Relationships Were So Complex

Is there a word for fear of math? If there isn't there really should be one because a lot of people seem to be scared by math more complex than figuring out a 15% tip when the check comes. This fear of math is really a shame because modern science puts math right at the very center of the way the world works. Math is really nothing but a condensed way of expressing relationships. This is why, even in the most intimidating and esoteric branches of mathematics you will always come across one familiar symbol, the humble 'equals' sign—the relationship of all the bits on the right is the same as the relationship of all the bits and pieces on the left.

Mathematics is a symbolic expression of relationship, and, according to quantum physics, reality is mainly relationship and very little else.

You might think, at this point, that while there is relationship in the universe, aren't there also the things that are doing the relating? Not so, because when you take away all the relationships, you find there's nothing left. A good illustration of this removal of relationship is provided in the history of stars, of which our Sun, of course, is the most familiar.

Taking Away Relationship

The Sun is much more massive than our earth and the force of gravity is that much more intense. Without some outwards force to counteract this inwards pull the Sun would rapidly collapse. This expansive force is provided by a high temperature. The Sun is fifty million degrees at its center (just a little hotter than New York City this summer) and this keeps the sun so expanded that overall it is only about as dense as water.

The Sun is losing heat all the time, of course, as any sun-tanner can testify even from a distance of 93 million miles away. To stay hot, the Sun uses fuel in a way similar to the hydrogen bomb. One of these days, however, (billions of years actually) the sun is going to use up all its fuel so there will be no way to maintain the high temperature. At that point, gravity will have its way and the sun will collapse, compressing all the atoms so tightly together that the sun will become one giant molecule, and the repulsion of the electrons will resist further collapse. At this point, the sun will eventually shrink to about a little bit less than the size of the earth, a so called

'white dwarf.' This is the ultimate fate of our own dear Sun.

Electrons, however, can only resist a certain amount of pressure, and when a star that is bigger than our Sun runs out of fuel, the electrons cannot resist the inwards pull and they get pressed into the atomic nucleus where they combine with the protons to form neutrons. The collapse continues until all the atoms become neutrons. Neutrons are tough, and they can halt the collapse at this point and this type of star ends its life as a giant atom about the size of Manhattan. These neutron stars, these remnants of once massive stars, have been found by astronomers because, even though they are so tiny (astronomically speaking) they spin very fast and send out pulsating beams of radio and X rays.

If the star is so massive that even the neutrons start to buckle, then the collapse continues and the star gets smaller and denser until the gravitational pull becomes so intense that even light cannot escape. This makes their direct study rather difficult, but they do have predictable effects on other nearby objects. These effects have allowed astronomers to detect an immense black hole, millions of times more massive than the Sun, at the center of our own Milky Way galaxy. What can stop such a collapse? We know that neutrons have a structure, they are made up of much smaller entities called quarks and the Super String theory of quantum physics suggests a size for them. If a collapse continued until all the quarks were in contact then a massive star could fit into something as small as a single proton. We can confidently predict that quarks will be made up of even smaller things. This must be so because in the beginning the whole universe was contained in a very small space. In a recent excellent series of articles "Making the Quantum Leap" in The Christian Science Monitor, Fermilab director Leon M. Lederman stated this quite clearly, "The whole solar system and the billions of solar systems that make the Milky Way galaxy, and the billions of [other] galaxies—all that stuff existed in a domain smaller than a pinhead on a pinhead in the early universe."

So, to get back to the importance of mathematics in science, whatever there is in this universe other than relationship, there's not very much of it. This is why math is so significant, it is our symbolic way of describing relationship, and that's all there is.

Fractals

A major recent advance in our ability to mathematically describe the relationships of nature is the development of fractals. Fractal relationships often appear in nature, and fractal mathematics can be used to generate 'natural' looking objects such as mountain ranges and clouds.

Fractals involve a class of numbers called complex numbers. Complex numbers have been around for some time in the world of 'pure mathematics' i.e. having no relationship to the real world, or so it seemed, but they are now to be found at the foundations of fractal mathematics.

Both fractals and complex numbers involve the concept of 'dimension.' Mathematicians use dimensions to discuss things that are totally different from each other, in math, when something is totally different to something else they are considered to be in different dimensions. A familiar example is height and width.

How wide is height? It has no width. How high is width? It has no height. Height has no width and width has no height, they've got nothing to do with each other. In mathematical terms we say that width has no extension in height and height has no extension in width.

In mathematics, this 'nothing to do with each other' is exactly the relationship between the real numbers and the imaginary numbers.

The real numbers embrace examples such as 1, 2, 3, -1, -2, -3, 1/3, 2/3, pi, infinity, etc. These are the numbers we are most familiar with.

Imaginary numbers are totally different to real numbers. All real numbers can be expressed as being multiples of one. Imaginary numbers, on the other hand, are multiples of something that doesn't exist, the square root of minus one. I bet you a million dollars that you never find a real number that, when multiplied by itself, gives you minus one.

The square root of minus one is denoted by the letter "i" so i times i equals minus one. There is a whole set of imaginary numbers that match the real ones but have nothing to do with them, 1i, 2i, 3i, -1i, -2i, -3i, 1/3i, 2/3i, (pi)i, (infinity)i, etc.

Real and imaginary numbers are two different dimensions, they've got nothing to do with each other, just like height and width in every day life have nothing to do with each other. So a real number has no extension in the dimension of the imaginary numbers and imaginary numbers have no extension in the real number dimension.

We have already discussed that in our four dimensional universe there seems to be a big difference between the three dimensions of space and the dimension of time. You probably guessed it already, time is described with imaginary numbers in Einstein's equations of relativity while space is described by real ones.

Complex Numbers

Both real and imaginary numbers are considered to be 'simple' numbers. Quantum physics, on the other hand, uses another class of numbers to describe reality, the complex numbers. These numbers have a real part as well as an imaginary part. So a complex number looks something like 2 + 3i, or - 5.6 + 4i - 2.6j + 88k.

What makes complex numbers so useful is that they are the basis of fractal mathematics. This new branch of mathematics has opened new ground because complex numbers have properties that neither real or imaginary

numbers have by themselves. They do strange things. In comparison, the real and imaginary numbers are boringly predictable. For instance, if you repeatedly multiply a simple number by itself, it just gets bigger.

Complex numbers, on the other hand, don't all behave in the same way, they have their own unique 'personality'. Some numbers get bigger, some fluctuate back and forth around a certain point, others stay the same. If you plot the real component of a complex number along the horizontal axis and the imaginary component on the vertical, each complex number has a position on this 'complex plane.' Perform some operation on each number, such as repetitive multiplication. Mark a number that stays the same in white, mark a number that rapidly gets bigger in black, and mark numbers between these two extremes in shades of gray. You will end up with something like the illustration. Some beautiful examples in color of these figures can be found in Scientific American and "The Beauty of Fractals" (H. Peitgen and P. Richter, 1986)

According to quantum physics reality, no matter how complicated, can be described using these complex numbers. So if you aspire to think the way God thinks, at least scientifically, you'd better start studying complex numbers. And that also explains why your relationships are so complex (I assume they are, I haven't met someone with them)—that's all the universes is, after all, complex relationships.

17. TELEPORTATION AND THE COMING KINGDOM

Down poured the rain as I, along with thousands of other dispirited commuters, sloshed my way towards Grand Central terminal and the train to Westchester. Not for the first time, my thoughts turned to how much time is wasted just getting from one place to another—all those billions of hours the human race spends sitting in cars and trains and boats and planes just to get from one place to someplace else.

Fearing the onset of a depression to match the weather, I quickly comforted myself with the thought that, even though it would not emerge in my lifetime, yet another step towards teleportation had recently been accomplished in the laboratory.

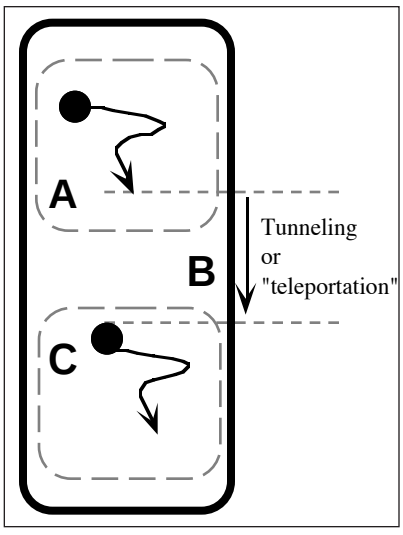
Of course, teleportation—the travel from one place to another without the bother of having to traverse all the intervening places—has been around for some time in the fertile imaginations of science-fiction writers—"Beam me up, Scotty" being just the most famous of the genre.

Indubitably, the scientist's task of creating a real teleportation device is a lot more complicated than the author's, who can offhandedly scribble "and the multiphasic neutronium plexitron hummed and her living room was replaced by the IRS office on Mars"—but an honest-to-goodness real step in the right direction just recently happened. Mind you, it was just one atom and the distance was only millimeters, but it was real matter and it was the second step towards real teleportation.

It is not something you learn in high school (but then, what is, these days), but the first step happened decades ago and now features in commercially-available devices. The step up from no teleportation to a microscopic amount of it involved electrons, just bits of atoms, in the phenomenon known as tunneling.

Tunneling

Schematically, this remarkable phenomenon—which is totally impossible according to the old-science view of matter—involves an electron zipping around in area A appearing in area C without ever being in area B.



It is clearly very difficult to explain such phenomena with classical 'billiard-ball' type physics. Such quantum tunneling occurs because, while the electron has a probability of being in A and a probability of being in C, it has a zero probability of being in B.

Unfortunately for the reluctant commuter, such 'teleportation' tendencies of electrons usually cancel each other—tunneling devices have to be designed very craftily to bring out this side of the electron's character.

This is why, even though we are basically just a mass of electrons (along with some nuclear matter to keep it all together), we can only move from one place to another by sequentially traversing all the intervening space. Thus the slosh through the rain. Overall, however, I must admit that this cancellation is a Good Thing, as otherwise our electrons would be bopping about all over the cosmos instead of sticking around and giving us a body to commute with in the first place.

The modern explanation for such odd behavior is that the electron is ruled by what is called its wavefunction, an abstract aspect internal to the electron that decides (on a very primitive level, to be sure) what the electron will do. This inherent directive aspect of the electron—call it its mind, if you must—creates the probability of finding the electron somewhere. And mind is master: if the wavefunction says be in area A and area C but never in area B, the 'body' of the electron obeys.

Measuring the mind

One of the great triumphs of the new physics is that it has a highly accurate mathematical description of the mind-like wavefunction as a set of "probability amplitudes," one for each of the possible things the electron might do (such as go from area A to area B).

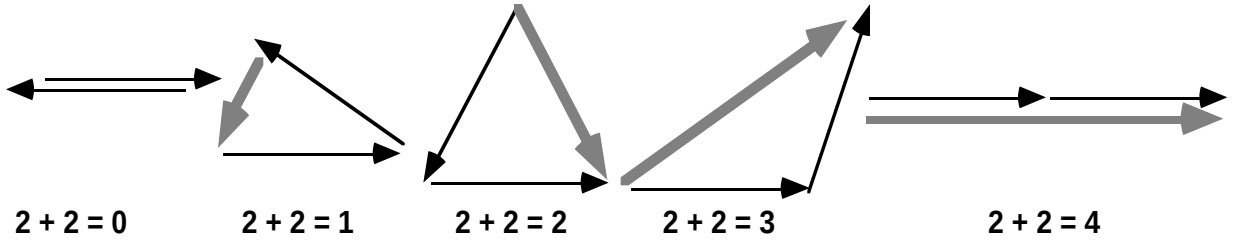
The techniques using probability amplitude have been remarkably successful and accurate. As Richard. P. Feynman, one of its pioneers, has noted: "The theory of quantum electrodynamics has now lasted more than fifty years and has been tested more and more accurately over a wider and wider range of conditions. At the present time I can proudly say that there is *no significant difference* between experiment and theory! … To give you a feeling for the accuracy [of the quantum description of the electron]: if you were to measure the distance from Los Angeles to New York to this accuracy, it would be exact to the thickness of a human hair. That's how delicately quantum electrodynamics has, in the last fifty years, been checked—both theoretically and experimentally" (*QED: The Strange Theory of Light and Matter* Princeton U Press (1985), p. 7).

Hardly modest, but then his recent obituary did merit almost a full page in *The New York Times*.

The measurement of a probability amplitude is complex—not in the sense of not being simple, but in the mathematical sense of needing a sophisticated kind of number called complex.

The key characteristic of the regular numbers we use every day (the real numbers to a math major) is that they have a magnitude, a size—2 is bigger than 1, 4 is bigger than 2, etc. The complex numbers, on the other hand, have an imaginary side to them as well as a real one (see previous column or any math book) which gives them another characteristic—they have a direction as well as a size—think of them as little arrows and you'll do fine.

Now if you were ever bored in school by the monotony of 2 + 2 = 4, you will love the diversity of complex numbers, where 2+2 can be any number of a variety of answers—the direction has to be taken into account as well as the size.



A very simple and widely used technique used to calculate with probability amplitudes in QED uses this representation of the complex numbers in a method, technically known as 'Feynman diagrams,' but often called "adding little arrows."

The wavefunction of the electron—its mind, so to speak—is a set of probability amplitudes, a set of little arrows. These arrows, of course, are not pointing anywhere in regular space, they are pointing in abstract dimensions, the so-called internal spaces of the electron.

This is how tunneling makes sense. All the little arrows combine to give a big probability of going from area A to area C and back again—like 2+2=4. But all the little arrows for going from A or C into B cancel out—like 2+2=0—and the electron never goes there. The electron, unlike others I know, does not have a problem with mind-body unity.

This behavior of the electron has been around for decades. Now matter is made of atoms, and atoms are made up of electrons and quarks (particles that can teleport just like the electron but are a lot more reclusive.) So, while it is obvious that in regular matter the teleportation tendencies of electrons and quarks cancel out—the 2+2=0 type situation—there is, in principle, no reason why, given the right set-up, these teleportation-tendencies can not be encouraged to emerge—just as it took careful design to get the electron to reveal its tunneling propensities.

This has happened, the second step towards real teleportation I mentioned in the beginning. Just recently they got atoms in the lab to interfere with each other, to exhibit the 2+2=0 type of behavior that underlies teleportation.

In the spring of 1991 four different laboratories independently demonstrated the interference of atoms. "The first to report was Professor Jürgen Mlynek.… The sketch of [his] apparatus might have come from Young's own papers: the experiment itself was a repetition of the original 1803 version, with the crucial difference that the slits were irradiated not by sunlight but by a stream of material particles.… The most mysterious feature of the experiment …is the fact that each atom traversed the apparatus alone, uninfluenced by the jostle of other particles."[1]

As atoms are considered to be "real" matter (no one has much to say about what electrons or photons are) such experiments can be considered to be exploring the teleportation of matter. Commercial applications, it should be noted, are probably quite a way off.

The next step is just one of scale, how to get a quintillion, quintillion atoms to do it all at the same time. Once

[1] Hans Christian von Baeyer *Taming the Atom: Emergence of the Visible Microworld*, Random House, NY 1992, p. 166–7

that's done, Sony, no doubt, will be ready to bring out its portable teleportation device—the No-Walkman, perhaps.

Extension

The new-physics understanding of the electron's internal aspects has some profound implications for philosophers as well as for commuters hoping to avoid the rain.

The chance-and-accident perspective of evolution founded by Darwin is built upon the mechanistic perspective of matter developed by Newton and, as he was the first to admit, "If I have seen further it is by standing on the shoulders of giants." One of those upon whom Newton clambered was Rene Descartes.

Before Descartes, there was little impetus to explore the world through the methods of science because the world of material was inextricably mixed in with the realm of the mind. Descartes, however, separated them; he divided the world into two sets of the *res extensa* (extended things) and *res cogitans* (thinking things). To him, the great difference between mind and material was that matter has extension while mind does not.

With mind and matter dissociated, Newton was free to explore the workings of the material world without reference to the realm of the mind—and, in the process, gave birth to modern science.

Later, Darwin would articulate his vision of the chance-and-accident origin of species based on the mechanistic concepts of Newton and the mind-less matter of Descartes.

But, as we have just seen, Descartes was wrong. You cannot differentiate between mind and matter using extension.

The mind—the inherent directive aspect of the electron measured by the little arrows—also has extension; it's just that it's in an internal dimension rather than an external one.

Just as it took Einstein to reveal that the belief in the absolute reality of physical extension was mistaken—it is an artifact of the fact that we habitually travel around at speeds significantly slower than that of light—quantum physics says that the division into mind and body is also mistaken—it is an artifact of a limitation of our senses as we cannot directly perceive extension in an internal dimension—just its projection as probability.

So teleportation takes another tiny step out of the pages of science fiction into everyday life. How wonderful to think that the Kingdom of Heaven will not just be a place where the major ills of our age will seem as a nightmare—even the minor nuisances will be gone. Step into the booth, dial home—or Seoul, or the Andromeda galaxy—step out: simple. As for sloshing about in the rain, I'm sure people will still do it, but only when they want to.

Well, those thoughts cheered me up no end—here's the station. Now for the slosh to the car, the slosh from car to front door, and I'm home. Primitive!! Tell me about it!

18. THE SUPERSTRING SPIRIT WORLD

Looking back, I must have seemed a rather precocious little brat, one of those kids who was always asking questions and never getting satisfied with the answers. This made life very difficult for my Sunday School teacher, a pious, if strict, nun with the name of Sister Benignus—and that her name sufficiently rhymed with 'big knickers' didn't help her one iota either.

She made an heroic effort to instill in us one of the basic principles of the faith: If you are good you will go to heaven, if you are bad you will go to hell. I drove her wild with my insistence on knowing exactly where these places were. I already knew enough about astronomy—certainly a lot more than she—to know that 'up in the sky' just wasn't good enough an answer for one as sophisticated as I. And perhaps, if she was uncertain about this one aspect, I thought, perhaps the rest of her ideas was not so solidly based either. I did warn you, I was a brat and a half.

Any modern religion cannot allow such uncertainty to cloud its moral and ethical teachings. The only real solution is to have a physical realm and a spiritual realm that do not relate to each other. These two realms coexist side by side, intermingling and interpenetrating, but having nothing to do with each other, with the obvious exception of human beings.

Most things are either one or the other. Most things seem to belong to the material realm and are made of physical constituents such as electrons, protons and neutrons. A few other things (that only certain people seem to be aware of) seem to belong purely to the spiritual realm—ghosts and angels spring to mind. Human beings, on the other hand, seem to be unique in having a physical part and a spiritual part—this perhaps being one of the few points that most religions seem to agree on. But is there any room in science for this spirit realm that has so little to do with the familiar physical realm? Surprisingly, recent developments seem to answer 'yes.'

Breaking Up

Science has made great strides forward in finding out just what the physical constituents are that make up our familiar material world. The first great insight was that all the myriads of different things around us that appear to be very different were actually composed of just a few elements in different combinations.

The next step was the discovery that the elements were themselves composed of different combinations of three subatomic particles: electrons, protons and neutrons. The electron is a member of a family of particles called

'leptons' (there are six of them all together). More sophisticated experiments indicated that the protons and neutrons were composite, they were made up of even smaller particles called quarks. There are also six of these (six 'flavors' with names such as 'up' and 'down') which come in three different 'colors.' No, I'm not pulling your leg about those names, physics has got so esoteric these days that it is perhaps inevitable that a little whimsy would creep in now and again.

So all matter is made up of various combinations of leptons and quarks which are lumped together under the name 'fermions.' For instance, the simplest bit of familiar matter is the hydrogen atom and this is composed of one electron, two 'up' quarks and one 'down' quark.

Now these bits and pieces do not exist in isolation, they relate to each other in very specific ways. Anything that has mass or energy is attracted towards anything else that has mass or energy. We call this interaction "gravity" which is responsible for large scale structure of the universe. All the fermions respond to gravity.

Certain particles relate in other ways. There is the electro-magnetic interaction between particles which have a quality called 'charge.' Electrons and quarks have charge and the electromagnetic force is responsible for the relationship between the atomic nucleus (where all the quarks hang out) and the orbiting electrons, the relationships between the atoms, molecules etc. In fact the electromagnetic interaction is responsible for most all familiar things we sense as light, sound, solidity, taste and smell.

Another interaction is the recently discovered 'weak force'—which is involved in radioactive decay and now seems to be an aspect of the electromagnetic force—and the 'strong force' which is mainly concerned with holding the quarks in the atomic nucleus together.

The greatest challenge in physics these days is trying to understand these interactions. The problem is that there is a fundamental split in the way modern physics explains these interactions with gravity by itself in one camp and the other three interactions together in the other.

The electromagnetic, weak and strong interactions are very well characterized in quantum mechanics. The interactions all occur by the exchange of a new category of particles, the bosons. The basic pattern is that fermions interact by exchanging bosons. The most familiar boson is the particle of light (the photon) which is exchanged in the electro-magnetic interaction. This quantum mechanical description of interactions works excellently for the three.

The problem is that it does not deal with gravity. Since Einstein and the theory of relativity, gravity has best been described as a deformation of four-dimensional space-time which has made the integration of gravity and the other forces into one consistent whole very difficult.

So, until recently, it seemed that the physical realm was a bit of a hodgepodge with two different types of particles—the 'matter' ones and the 'messenger' ones—and gravity. And no one really knew how to integrate them all together into one consistent theory. Even Einstein failed in his attempt to unify them together.

Superstrings

However, into the confusion has come a rescuer. This Clark Kent of theoretical physics is called 'superstring theory.' Don't ask me to go into the math of it as it is considered difficult even by those whose bread-and-butter is the intricacies of physics. But in essence, it says that our universe has 9 geometric dimensions. Six of these dimensions are rolled up into tiny little strings that— depending on the way they vibrate, or if they are open or closed, and the way they attach themselves to each other—appear to us as 'matter' particles, 'messenger' particles, or gravity. The 3 dimensions that are not rolled up are the ones we perceive as our familiar up and down, left and right, and forward and backwards.

In the article "A Theory of Everything" in the February 1986 issue of "Science Digest", Michael D. Lemonick asserts that "superstring theory has the potential to explain just about everything in physics: why there are four fundamental forces in nature; why we see the subatomic particles we do; how gravity and quantum theory can at last be united."

These 'strings' of rolled up dimensions are not something that can be easily examined as they are very, very, very, very small. Something on the order of 'a decimal point followed by thirty four zeros' of an inch. In comparison, the atomic nucleus is huge: on the order of 'a decimal point followed by only fourteen zeros' of an inch. Which, in comparison, is merely very, very small.

Ghost Matter

This advance in theoretical physics has been neatly summarized in an article in the excellent 'Science and Technology' section of "The Economist." (Jan. 18, 1986) According to this article, of the two mathematical models of superstrings being discussed, one of them—given the delightfully esoteric label 'the E8xE8 symmetry group'—seems superior in explaining and predicting the world we live in. However, there is big enigma contained in the mathematical explanation as:

"It is a sort of 'double group', one side of which might ..... give rise to the right particles. What about the other side? This is where things get really interesting. This might represent a twin universe. It could describe (another) set of string particles ..... The point about such a universe is that the mathematics seems to predict that the two universes would be entirely independent of each other ..... The electromagnetic force, for example, would not carry between the two types of matter, so the two would be invisible to each other ....."

So there you have it. Science—and this is hard, mainstream stuff and not the hippy-dippy 'soft' variety—talking about two realms that 'coexist side by side, intermingling and interpenetrating, but having nothing to do with each other' which sounds remarkably similar to the basic viewpoint of religion—there is something other that just the physical realm.

The article also points out that, according to this new theory, gravity should effect both realms. Now one of the big questions facing scientists who are dealing with the 'big' questions of the universe—the very, very, very scale questions of the astrophysicists—is that the calculated mass of the universe needed to explain it's structure is hundreds of times greater than the observed mass of the universe.

There are many theories now circulating around attempting to explain this discrepancy, the invisible 'ghost matter' Perhaps the answer is that the 'ghost matter' of the universe is actually ghost matter.

However, getting back to theology. At last, after so many years of being a barrier to faith, modern science is coming to the rescue of Sister Benignus and her struggle with precocious little brats.

Now when they ask, "Where is heaven, where is hell" she can say with confidence, "It is all around you, you just can't see it. One day when you are old enough, and have mastered higher math, you will be able to understand the E8xE8 theory of superstrings and the invisible matter of spirit world. But until then, Be Good To Your Mother And Father and Say Your Prayers. Or else ..."

19. Probably an Improbable Book

I received an unexpected, and thereby all the more delicious, warm fuzzy one day when a college evangelical asked me to write for a student publication.

He asked if I could write about evolution because had found, in his evangelical work on campuses, that the materialistic, mechanistic perspective derived from Darwin's insights was a great block to people understanding God.

The reason why the materialistic, mechanistic perspective in science has been so successful has been summarized nicely by Steven Jay Gould, professor of Geology at Harvard. In his February '85 "This View of Life" column in Natural History about "Nasty Little Facts" he noted that:

"We know ... ties of genealogy connect all living things on our planet, because these theories assemble and explain so much disparate and unrelated information."

The materialistic, mechanistic view of science, and particularly evolutionary theory, ties a lot of little bits of information and fact together in a nice neat package. If there is to be any hope of a new viewpoint catching on in a big way it had better tie the package together better and also include the little bits that refused to fit into the old package.

Dr. Gould also points out that "In science, one little fact, like a single foot soldier, almost never decides a great battle." So in the historical battle of the viewpoints "God" and "No God" there is little point in looking for the fact that will cause the collapse of materialism. Instead, there has to be an assault on many fronts. As Dr. Gould encourages (I am sure unintentionally):

"Large numbers of little facts may eventually combine with other social and intellectual forces to topple a grand theory. The history of ideas is a play of complex human passions interacting with an external reality only slightly less intricate."

Thermodamnation

One of these 'foot soldiers' is the fact of 'form.' It is quite clear from our daily experience that the simple laws of physics and chemistry are not sufficient to explain the world around us.

An excellent example is the book you are reading.

I am not for one instance suggesting that this book is a miracle (although the closer I got to deadline the more I wished it was) and I am not suggesting that this book is not a law-of-nature abiding entity. However, thermodynamically speaking, it is a highly improbable entity. The journey from tree to pulp to paper to printer to bookstore to you obeys every natural law, yet, just looking at the sequence that occurs, it is highly improbable. At each step there were many equally probable lawful events that could occur.

No less improbable is this article. In it are about 9000 letters and characters. Now all the possible combinations of the 60-odd upper and lower letters etc. are energetically equally likely—that this particular one is here is highly unlikely. Updating and disproving the old enough-monkeys-hitting-a-typewriter-for-long-enough-will-produce-Shakespear idea: There are roughly (according to my Mac computer—another highly improbable aggregate of sand and plastic) 1-followed-by-15,250-zeros equally possible combinations. Even the most ideal sort of super miniature computer that could create and examine a billion billion billion billion combinations using only the energy obtained by the annihilation of a single subatomic particle would use up the entire mass-energy of the whole universe and still not reached 1-followed-by-200-zeros combinations. Yet this particular combination is here. It only took 3 hours and a few watts to run my word processor and here it is.

Look around you, almost everything—the table, the chair, the lights—is most improbable from a laws-of-nature point of view.

The Second Law

One of the laws of physics that often pops up in the 'God' and 'No God' debate is the second law of thermodynamics. The first law is that energy is neither created or destroyed, the second law states that disorder (technically a concept called entropy) always increases.

An easy mistake to make is the claim that 'life' is incompatible with the second law as life promotes order. But if you look closely, we see that life promotes order in one place by increasing the disorder in others.

If you look at the balance sheet before and after—the energy in sunlight which was captured by the plants which were eaten by me to provide the energy to type this piece—a lot of general disorder was introduced to result in the localized order that is me typing. I assure you that I am a thoroughly law-of-nature abiding citizen.

The element that makes these extraordinarily unlikely situations happen, these highly improbable chairs, tables and books, is the element of mind. Mind has the capacity to organize material. The invisible ideas of human beings have been expressed in the man-made things we see around us—man-made things have an invisible idea part and they have a visible, material part.

But this is the same situation in natural objects as well. The ordering, the form of natural objects is caused by the equivalent of the probability field of quantum physics, an invisible, mathematical type of entity. Thus natural objects also have an invisible part and a visible, material part. In both natural and man-made objects, the form of the invisible part is expressed in the visible part by making highly improbable patterns and events actually happen.

It is this similarity between natural and man-made objects that supports a religious person who insists that these probability fields are actually ideas from the mind of God.

20. THERE IS MORE TO MATTER THAN MATTER ALONE

I delight in the writings of C. S. Lewis—no relationship I'm sorry to say—and I was not disappointed by "God in the Dock—Essays on Theology and Ethics."

As a convert from 'hedonistic materialism,' I was tickled by the way he brushes off the theories of pure materialism:

"If [as the materialist holds] the solar system is an accident and the appearance of life is an accident and the evolution of Man is an accident then all our present thoughts are mere accidents—the accidental by-product of the movement of atoms. And this holds for all the thoughts of the materialist as well as for anyone else. But if their thoughts are merely accidental by-products why should we believe them to be true. Why should one accident be a true account of another accident?"

I felt this in a particularly intense way while watching one of those excellent science programs on PBS television, I think it was "The Brain."

A learned neuroscientist spoke earnestly into the camera about the brain—how it was just a complex mass of reflex arcs and chemical interactions. To those with eyes to see, however, he was a living refutation of his words: His image spoke through the complexity of camera-antenna-color TV, behind him was bookcase upon bookcase of learned journals, on the wall a van Gogh print swirled, in the background Beethoven's 5th swelled and murmured—while the "reflex arcs and chemicals" argued eloquently and persuasively—if disparagingly—about itself.

My mind—not reflex arcs to be sure—boggled at the contradiction between his words and the beauty and complexity of the reality.

Nothing but Everything

The most up-to date thinking about sub-atomic particles—the quantum theory—describes the world in terms of "probability functions." At this level of reality the pattern is more "real" than the "material" it is expressed in.

This, however, is not so strange. It is, after all, what we are very used to—almost everything around us is there because it was manufactured, transported and placed according to the patterns imposed by the thoughts of people.

What makes a computer chip different from sand—the thought put into it. What makes you more than a gelled soup of chemicals—the pattern in which they are arranged.

A critique of the view that puts material—not the pattern—in the position of prime importance is one of the strengths of the Creation Science movement in America. This attack on materialism is illustrated by a prominent Creationist, Dr. Gary E. Parker, in his book "What is Creation Science," when he asks the question: "Did you ever wonder what makes an airplane fly?"

"Take the wings off and study them; they don't fly. Take the engines off and study them; they don't fly. Take the little man out of the cockpit, study him; he doesn't fly. Don't dwell on this next time you're on a airplane, but an airplane is a collection of non-flying parts! Not a single part of it flies!"

Reading this reminded me of my days of as a biochemical researcher. From experience I can tell you that the first step in any biochemical experiment is: Put whatever it is you want to understand into the Waring blender—a high-tech, expensive version of the milk-shake maker—and whoosh it around until there are no more lumps.

Then try to figure out how it works.

How many guinea-pig lungs and rat livers I minced up in my time, searching for the elusive secrets of life, I am loath to recall. And each time I did I was disrupting the very thing I was searching for.

As one wit in the magazine New Scientist put it many years ago: Put a color TV in a cement mixer, churn it around until it is a fine powder and then try figuring out just how a TV works. There, you now understand Biochemistry and its effort to understand life.

To be fair, scientists are beginning to realize—and to look for—the organizing principle. Dr. Parker, as a theist and a scientist, is on the look out for such developments. He quotes in his book an interesting conclusion made by Dr. Dickerson in the Scientific American booklet "Evolution:"

"After describing the problems in producing the right kinds of molecules for living systems, Dickerson says that those droplets that 'by sheer chance' contained the right kinds of molecules survived longer. He continues, 'This is not life, but it is getting close to it. The missing ingredient is ...' What will he say here? ... one more protein? ... a little more DNA? ... an energy supply? ... the right acid-base balance? No, he says: 'The missing ingredient is an orderly mechanism ...' An orderly mechanism! That's what's missing—but that is what life is all about—not a property of substance but a property of organization."

Ideas

A religious person will say that the patterns, the ordering we see in nature are 'God's thoughts,' they are ideas from God. This is quite allowable in the scientific view as it relates to the scientific view of what ideas are.

In the science view, ideas are patterns. Take an idea in the mind of an artist. At one point the idea for a painting about flowers was just a pattern of firing and non-firing in the neurons in the brain of Vincent van Gogh. (Note, however, that this is not the same as saying that the pattern of neuronal firing created the idea—science has no theories as to how that happens.) This pattern in Vincent's central nervous system moved into the peripheral nervous system where it moved the muscles which moved the paintbrush which moved the paint into a pattern that captured his concept of sunflowers. A bank recently forked out $37,000,000 or so for this bunch of flowers, but you can bet that it wasn't the $5 worth of oil paint they were after as an asset. It is the idea, the pattern, captured there by the genius of van Gogh that made the painting a worthwhile investment.

Just as the valuable painting is the result of the reorganization of valueless oil paint, so the world of nature is created by the reorganization of simpler things.

Plants and animals are the result of the organization of cells. Cells are the result of the organization of molecules such as proteins, carbohydrates, lipids (a polite word for fat) etc. Molecules are the result of the organization of atoms, atoms of sub-atomic particles—electrons, protons and neutrons—created during the "Let there be Light" cataclysm of the "Big Bang."

So there is nothing scientifically unacceptable about saying that the patterns in nature are God's thoughts, but there is a difference of opinion as to how those thoughts get there.

Creationists take the easy way out. They say that God organized everything by personal command and then left things to continue by themselves. This is where Creationism leaves the scientific fold.

To my mind, the true spirit of religion in science is explained by James S. Trefil at the end of his book "The Moment of Creation:"

"I feel much more comfortable with the concept of a God who is clever enough to devise the laws of physics that make the existence of our marvelous universe inevitable than I do with the old-fashioned God who had to make it all, laboriously, piece by piece."

Natural Law

The basis of science is a belief that the precise ways in which natural things are patterned is a result of the workings of natural law. It is left up to the individual to speculate as to where these natural laws come from. A scientist preferring materialist explanations might say that these laws are simply the way things happen to work—perhaps in another universe things would work differently. A theistic scientist can say that these laws are created by God.

No matter how different the explanation of where the laws come from, they are both talking about the same scientific laws—their different beliefs lie outside the realm of scientific proof or disproof.

A very good question now springs to mind: Why do things obey the law. As anyone who has lived in New York City can testify, having a law is one thing, obeying it another thing entirely. There is a 'law-enforcement agency' of the Universe (with humans, according to religion, the only 'criminals'—but that's another tale altogether).

Problems

So what is it that patterns material. One scientist who explored this question became so controversial that 'Nature,' one of the most prestigious scientific journals, declared that his book was "the best candidate for burning there has been in many years."

That book was "A New Science of Life" by Rupert Sheldrake. He roused the ire of the scientific establishment by taking a look at the fuzzy edges of modern biology—those areas where current theories are at a loss to even

come up with workable theories—and introducing the concept of a 'morphogenetic field' to explain:

— Morphogenesis: the development of the complete organism from the egg/seed, and genetic programs (which brings up the related question of the Great Genetic Programmer in the Sky, a question Dr. Sheldrake leaves for other explorers).

— The breakdown of development such as cancer.

— The intricate behavior patterns of organisms.

— the relationship of micro-evolution (the well-documented development of variation within a species through mutation and selection) and macro-evolution (the development of new species, genera, families etc.—the question of how a Fish becomes a Philosopher).

— Most puzzling to the mind—the mind itself.

The Blueprint

He describes this new field using the analogy of building a house:

"This idea [of the non-energetic, causation of form by this field] is easier to grasp with the help of an architectural analogy. In order to construct a house, bricks etc. are necessary; so are the builders who put the materials into place, and so is the architectural plan which determines the form of the house. ... Thus the plan can be regarded as the cause of the specific form of the house, although of course it is not the only cause: it could never be realized without the building materials and the activity of the builders. Similarly, a specific morphogenetic field is a cause of the specific form taken up by a system, although it cannot act without suitable 'building blocks' and without the energy necessary to move them into place."

What Dr. Sheldrake is pointing out is that the four 'energetic' forces—gravity, electromagnetism, the strong and the weak nuclear forces—is not enough to explain the reality we inhabit.

He maintains that in order to understand our world we need to add a new force field to those now thought to govern physical reality.

This is not a concept that is currently embraced by many scientists. Dr. Sheldrake, as a biologist who has manipulated test-tubes with the "creme de la creme" of the Royal Society and at Cambridge and Harvard, knew what sort of receptivity his peers would have for such ideas: "In the light of past successes, this optimism that all the problems of biology can ultimately be solved mechanistically is understandable. But a realistic opinion about the prospects for mechanistic explanation ... can only be formed after a consideration of the outstanding problems of biology."

What can this new force field be that causes form? Dr. Sheldrake makes an inspired suggestion.

Probability

It is certain that this force field is not involved with energy in the sense that chemistry and physics deal with cause and effect. "For although (these fields) can only bring about their effects in conjunction with energetic processes, they are not in themselves energetic."

Dr. Sheldrake makes the insightful suggestion that this field has its effect on matter through its influence on probability. His theory proposes that:

"Specific (fields) are responsible for the characteristic form and organization of systems at all levels of complexity, not only in the realm of biology, but also in the realms of chemistry and physics. These fields order the systems with which they are associated by affecting events which, from an energetic point of view, appear to be indeterminate or probabilistic; they impose patterned restrictions on the energetically possible outcomes of physical processes."

He does go on to discuss the origin of these fields, hypothesizing that they are derived from similar systems existing in the past (though he admits that this does not answer the question how the first occurrence of the pattern happened). Incidentally, this should not be taken as an encouragement to gambling, sitting at the craps table staring at the dice, mentally altering the probability of the throws.

Dr. Sheldrake gives the name 'morphogenetic field' to this force field that alters probability. We do not really need to invent a new concept, however, as there is a similar concept in the well developed foundations of quantum mechanics, a concept that has wide acceptance in the scientific world. This is the topic of the next chapter.

21. THE TASTE OF ROAST BEEF AND QUANTUM BIOLOGY

One of the most satisfying pursuits in science is that of grappling with 'loose ends,' those little facts that just don't fit into the view currently accepted by the scientific world. It's satisfying because with such a loose end you can ask yourself the question, "Just how would things have to be to make this loose end fit in?"

Many times the results of such reveries get you nowhere. Sometimes, however, they can lead into totally new realms. Einstein, for instance, found two such loose ends in classical Newtonian physics and was able to perform a double whammy while reorganizing physics to fit them both in. One of the loose ends was the unexpected nature of the photo-electric effect (everyone expected to find that light with higher energy would generate more

electric current; it didn't) which Einstein dealt with by developing the concept of the quantum nature of energy while the other was the unexpected result of the Michelson-Morley experiment (which failed to detect the ether that was supposed necessary for the transmission of light through the vacuum) which Einstein resolved by inventing relativity.

As I said, dealing with loose ends can be very productive sometimes. Since those breakthroughs, 20th century physics has developed a conceptual structure that is much more in harmony with the conceptual structure of religion than the mechanistic views of 19th century physics. Unlike physics, however, contemporary biology is still based on 19th century concepts and is still at odds with the fundamental principles of religion (a topic I've written about many times.)

Roast beef

There are, however, a lot of loose ends to be found in the conceptual structure of modern biology, many of which can be resolved by incorporating the concepts developed in quantum physics. One of the interesting loose ends in biology is represented by a question, "Why is roast beef delicious?"

Contemporary evolutionary theory, the unifying principle of all biology, can give no reason why the separate development of cow flesh and the human taste receptor should intersect in such a delightful way.

It could give a reason why raw beef might taste good. (The proto-humans who ate meat because it tasted good had better nutrition and did better in the reproductive sweepstakes than those who thought it tasted awful, selection for raw meat to taste good.) And it does although with limited appeal: I have a penchant for a little Steak Tartare and I have a friend who has been known to eat 1/2 lb of raw hamburger with apparent relish. But everyone—barring a few Californian types—likes the taste of roast beef.

But the roasting of meat has only been around for a few thousands of years, far too short a time for evolutionary natural selection to have brought these disparate parts of the animal kingdom into any sort of correspondence.

If you find this example not too your taste, consider aspects of nature more savory to the vegetarian, herbs. Pick up a book on herbal healing, there are thousands of plants with very specific effects of the human constitution. Some loosen you up, others calm your nerves, others get you up, others get you down. Most of the modern pharmacopoeia of drugs were discovered first in a plant or fungus. It is quite well documented that animals know what plants to eat to help them when they are sick.

Nature is riddled with these correspondences between humans and the animal, plants and mineral kingdom. As Darwinism, has no good explanation for this, we can consider it a real loose end.

If you are a religious person, of course, the answer to this problem of correspondence is simple: God designed it that way. This makes a great deal of sense if you believe in God but scientists (whether they believe or not) are not allowed to answer a question in this way. They have to stick with immediate causes (the 'efficient' cause of classical philosophy) when trying to explain the world we live in.

The remarkable thing, however, is that while 19th century physics offers no solution to this problem, 20th century physics does. Quantum physics actually requires that everything correspond to everything else. The reason is to do with waves.

Quantum waveforms

The 19th century physics description of the world was quite common sense, there were little particles of matter moving around in the empty vacuum interacting with one another, the physics most people learn in high school. Quantum physics, however, describes a world that is not at all common sense.

One of the core concepts of quantum physics is the probability field or wave function. It is these wave functions that are responsible for the shape and form of matter.

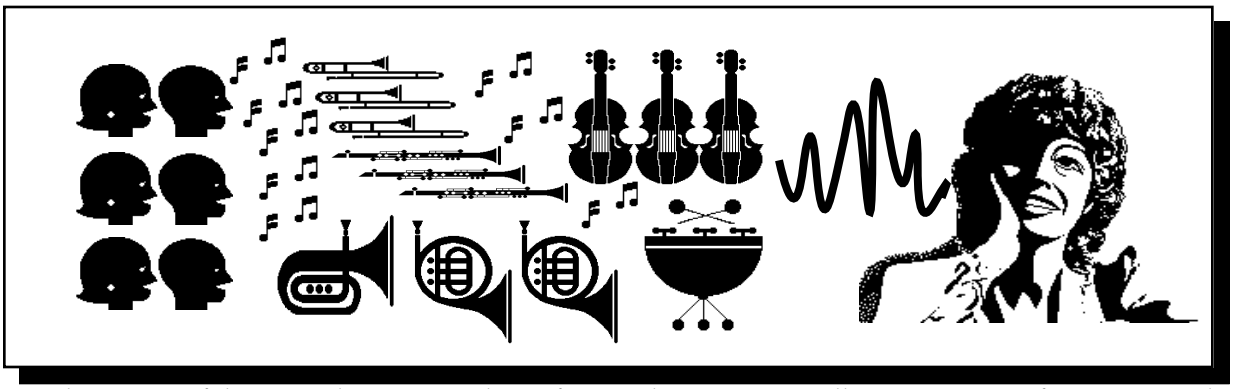
Everything has wave functions associated with it. Sub-sub-atomic particles have them, sub-atomic particles have them, atoms have them, molecules have them, cells have them, everything has them. In quantum physics everything can be described in terms of these waves. The mathematical tools at our disposal get bogged down in describing systems more complicated than the hydrogen atom, but in theory, anything can be described in this way.

Obviously, the waveform description of something as complicated as a cat is awesomely intricate. There are all the tiny waves of the sub-atomic particles, the larger ones of the atoms, the larger ones of the molecules etc. Now you might think that all these different waveforms were separate from one another. But one of the most interesting properties of waves is that no matter how complicated things get, it's still one wave.

Symphony

An excellent example of this is the orchestra. At the glorious climax of Beethoven's Ninth there are four soloists, a choir of 300 voices, 40 violins, 15 violas, 20 cellos, 10 contra basses, 4 french horns, 3 trumpets, 3 trombones, 2 oboes, 2 flutes, 2 clarinets, 2 bassoons, all sorts of percussion and a harp all belting away together. Each is producing a highly complex sound waveform. Air, however, does not carry each sound separately. Sound is transmitted as air pressure, and, at any instant, air can only have one pressure at a time. So that celestial music that can send shivvvvers of heavenly pleasure up and down your spine actually reaches you as a single

waveform.



The genius of the ear is that it instantly performs what scientists call a Fourier Transformation on that single incredibly complex waveform and separates out all the various components you perceive so well in that center seat six rows back. That is why you can clearly hear the soloist even though the orchestra is fiddling with great enthusiasm.

In the same way, all the waveforms that govern particles, atoms molecules etc. are all part of one highly complex waveform. Material objects can be considered to do a 'Fourier Transformation' and pick out their own particular wave function. For example, while a hydrogen atom obeys the natural law for hydrogen, it pays no attention to the natural law for water, it isn't relevant to a single atom.

So in quantum physics it is no surprise at all to find correspondence between different parts of the material world, we would actually be surprised if we didn't find any seeing as the same waveform was involved in every case.

And that's why roast beef is delicious.

22. PUTTING CAUSE AND EFFECT THE RIGHT WAY ROUND

While out for a snack with a musically sophisticated friend one day I tried to explain over Nachos Rancheros why it was unlikely that Creationism would topple Darwinism from its scientific pre-eminence. Sensing the need for a musical analogy, I asked him to name a composer of great intellectual stature. Without hesitation he anointed Bach. It took a lot longer to get him to pronounce judgment in the opposite direction, he said there were so many. He reluctantly offered Tammy Baker (but I said "she's suffered enough already") so he said "Willie Nelson" with an apologetic, "But some people think he's great."

I asked him what was the difference between Bach and Willie. It's one thing to be able to write a melody, he explained, but while Willie expresses a few simple concepts, Bach's music is an incredibly intricate manipulation of musical ideas.

After calling for more nachos as it was a long explanation, I told him that science was the same. While creationism's critique of Darwinism has merit, the simplistic concepts that creationists want to insert into scientific thought just will not fit in with the subtle and intricate edifice painstakingly erected over the years by scientists. "You mean the way you wouldn't try to use eighteenth-century baroque counterpoint techniques to analyze Willie Nelson's tunes." Precisely, I said changing the subject to the stock market about which we both know nothing.

Cause and effect

Creationism has many adherents as it is trying to deal with that great defect in modern Darwinism: its denial of God's role in creation. But proposals such as God creating new organisms out of nothing will never be accepted by those who have really studied the processes at work in Nature. The battle has to be fought on sciences own terms. There has to be a reworking of the scientific edifice of thought so that we can, if we choose, see God at work. As the whole edifice changes form when a few of the basic concepts are changed this is not too difficult.

In fact, most of the work involved in this reworking has already been done in the astounding changes wrought in physics. 20th century physics has become vastly different to nineteenth-century physics since the advent of relativity and quantum mechanics. Biology hasn't, however, made such a transition. If Darwin was the biological Newton who fused the parts into a brilliant whole where is the Einstein or Bohr.

Without meaning to make any claim whatsoever to such a position, we can tackle one of the basic concepts that was changed by quantum physics, the relationship between 'form' and 'force.'

Force and Form

We know of four basic forces at work in this universe. For those who like the details they are called gravity, electromagnetism, the 'strong' and the 'weak' force. In 19th century science such forces are considered to cause

matter to take up certain forms, the force causing the form For example, the electromagnetic force "causes" the hydrogen atom to form out of an electron and a proton.

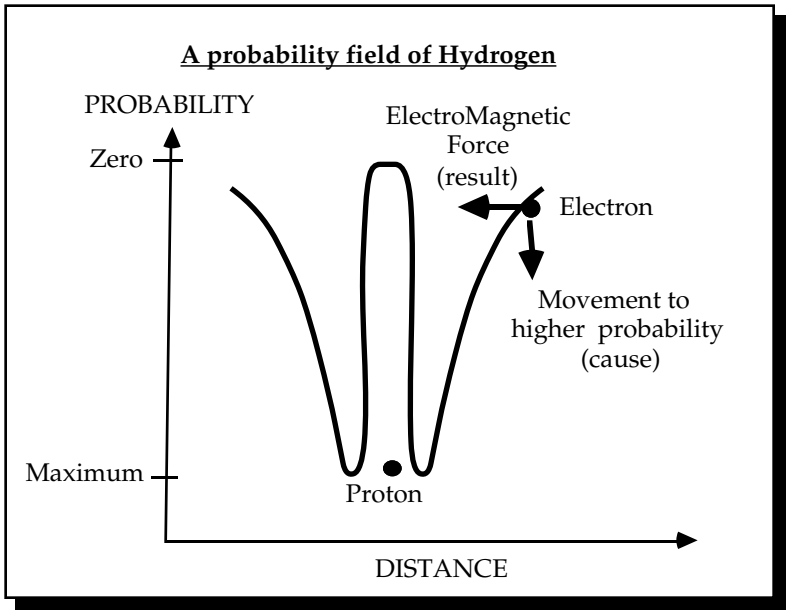
Biology is founded on this way of thinking while quantum mechanics has completely done away with it.

Before everything changed, for instance, physicists viewed the electromagnetic interaction as particles being acted upon by forces. Quantum theory, however, has a very different description of reality. The solutions to the equations describe an electron that is smeared out, it's not something so substantial. Instead of a point of matter there is now a 'probability field' which describes the relationship between the electron and proton. These probability fields have a certain form.

In the case of hydrogen our mathematical tools are capable of precisely describing this form although they can only approximate in systems more complex, (but that's our limitation.) We can illustrate the form of the probability field in hydrogen (called 'the 1S orbital') in the diagram. The value at each point in the probability field grades in from zero at far distance to a maximum near the proton falling rapidly back to zero closer in. The form of this probability field is like a circular moat surrounding the proton. There are also other solutions to the equations with names such as 1P, 2P etc. that have different forms.

One firm pillar of the scientific edifice is the well established tendency of matter to move from less probable states to more probable states, the basis of the second law of thermodynamics. So it is not surprising that the electron tends to move from regions of low probability to regions of high probability. In the diagram this can be visualized as 'falling' in the probability moat. While our eyes cannot perceive a change in probability, they can perceive a change in distance apart. Quantum mechanics says that the movement we usually describe as being the result of the electromagnetic force is actually caused by the movement in the probability field towards a state of higher probability.

All the basic forces can be described in the same way. In quantum mechanics, what we call an interaction is a property of the system that generates a probability field in which the system tends to change from a low to a high probability state. In quantum mechanics, the form is the cause of the force, not force the cause of the form.



An assumption in much of science is that a form arises because it happens to be one with the lowest energy. Looking at things energetically, just 'adding calories' so to speak, it is possible to calculate all the factors involved in the structure for the hydrogen atom—one electron and one proton. Everything else, however, is too complicated for even a Cray supercomputer to calculate.

However, the rough calculations that are possible for systems more complex than hydrogen seem to indicate a number of roughly equal low energy states which would be equally probable. Yet natural systems always takes on a very specific form and pattern. This diagram illustrates one of the solutions to the equations describing the electromagnetic interaction of an electron and a proton is called the 1S orbital.

This solution to the equations can be visualized as a probability field that has the form of a circular moat about the proton. The 'falling' towards a higher probability is described as being the result of the electromagnetic force.

Even at a fairly simple (for life) level, this is particularly noticeable in the highly complex protein molecules which convolute into very specific patterns. At the highest level of complexity, is the relationship between mind and body. For every invisible thought there is a pattern of neuron firing (which some might say was the thought itself) in the nervous system.

It has already been established, however, that the stimulation of one cell by another across the synapse is a probabilistic event and eminently suited to manipulated by probability fields which perhaps gives some clue to the enigmatic nature of the invisible mind itself.

If this seems a little strange to you, putting something as insubstantial as a mathematical formula in the causal role, it is not at all strange to modern physicists, they already embrace such concepts readily. In 'string' theory, currently the most sophisticated development of quantum mechanics, matter itself seems to be more an equation than anything at all material or substantial. "These strings are not, of course visible … impossible to detect by any means known to science today, they are mathematical curves." declared K. C. Cole in "A Theory of Everything" in The New York Times Magazine, Oct. 18, 1987

Our ability to understand the forms taken up by a system is highly dependent upon us knowing all the factors involved. If we are unaware of important factors our equations will fail to reflect what we actually observe. An historical example of this is the form of the hydrogen atom. Classical physics had a way of describing the electron/proton interaction that allowed the electron to take up an infinite number of energetic positions about the proton. Unfortunately, real electrons didn't behave at all like that, they took up relatively few. It was only when the quantum nature of energy was included was it possible to accurately describe the structure of the hydrogen atom.

Biologists are in a similar plight with their old ways of thinking. We have a way to go before we can deal with evolution; however, we can first apply these concepts to the biochemical problem, a convenient waystation lying between the non-life world of the physicist and that of the biologist.

A prediction

It is considered a healthy sign in a scientific theory if it can predict new phenomena because then you can do some testing. Let's take an unsolved problem and see if we can make some useful suggestion We will look at the problem of protein folding, although 'tangling' would be a more accurate description. Every protein is made by stringing together a long sequence of amino acids in a chain. These chains then tangle into balls of a very precise and compact shape. It is this ball which is biologically active, proteins doing almost all the work in living organisms. It is clear that the chain automatically tangles in the 'correct' way every time.

The big unknown is why? Scientists have already taken into account all the known interactions (with intimidating labels such as 'hydrophobic' and 'steric hindrance') and calculated the predicted forms.

But here they hit a snag, there are an immense number of solutions. It is just not possible for a protein to test all of these until it finds the right one, it would take too long. A small chain, as proteins go, of 150 amino-acids, for instance, testing a billion billion different configurations each second would take about a trillion trillion trillion years—a billion, billion times the age of the universe (I sound like Isaac Azimov)—to find the 'correct' configuration. Yet the refolding of a denatured (untangled) enzyme takes place in less than a minute.

We predict that there is an unknown interaction creating a probability field about the chain. The movement that correctly tangles the chain is caused by the falling in the probability field, which, just as we described for hydrogen, has a form. We see the chain seemingly selecting one form out of the other innumerable possibilities that otherwise seem to be energetically equally possible? If we understood the nature of this interaction, however, and included it into our calculations, we would find that there was only one form. Now the amino–acid chain is expected to make the transition from the untangled state to the precisely tangled one, just as we expect electron to 'fall' towards protons.

What is a good candidate for such an unknown interaction. My guess is that it will turn out to be the way a number of electrons interact and behave as a single entity over long distances. This phenomena is only poorly understood as witnessed by the mystery as to why the new, high-temperature ceramic superconductors work. A similar mechanism could be at work over the great lengths of large macromolecules such as proteins (and DNA for that matter.)

Anybody got any grant money?

Even though many scientists might not agree with this way of thinking, at least we are not resorting to a puff of magic to explain things. Move over Willie!

As you can see, we are not trying to 'prove' God. You can still believe "There is no God, that's just the way the universe is!" if you want, but at least there is now no aggressive denial of God implicit in our scientific edifice. If you want to believe that our reason can comprehend the equations that describe probability fields only because they were first thought of by God, that is your prerogative. It's the American way.

Now if that's not more satisfying than a plate of Nachos Rancheros you must really like Mexican restaurants.

23. Probability and Inherent Directive Nature

Those proverbial grindstones in the mill of God are renowned for the exceeding slowness, if exquisite fineness, of their grinding. This, along with Jesus' reminder that to seek is to find and to ask is to be answered, explains why sometimes answers do not pop out as quickly as if processed by a Cray supercomputer.

I once had a question that begged for an answer.

When I studied the *Divine Principle* in depth in 1975-76 I was awed by its simplicity and inner consistency. Raised with a thoroughly scientific education, I was aware that these are rare and admirable qualities found only in the most brilliant and illuminating of scientific insights.

A Question

One of the shortcomings of any theological teaching, however, is the tendency to state truths without bothering with rigorous explanations. At the roots of the Principle are a few concepts that seemed like this to me: a universal prime force that worked through a common base to cause relationship expressing an inherent directive nature that was equivalent to the mind in the higher organisms.

My question was, What did these things correspond to in the scientific view of the world?

"Natural law," I would answer when others asked me such questions. This is a very safe answer since science is just as vague as religion is when it comes to clearly explaining exactly what a natural law is or does.

I pondered upon this question, even prayed about it, a good deal in those early years. As no answer was forthcoming, eventually I put my notes in a folder and filed them away and forgot about it.

I am happy to report, however, that the mills have ground around and that the riddle has been resolved. As is the way with such things, the explanation appeared in the course of working on a quite different project.

The project consists of writing a book based on quantum physics. My work on this has entailed not only getting a grasp of modern physics but also reading up on the mathematics which pervades the language of all science. Both, it turned out, provide parts of the answer.

Relationship

My first step was to realize that quantum physics totally agreed with the Principle in that the fundamental nature of reality is relationship, what scientists call 'interaction.'

There are only four basic interactions, the fundamental ways in which material things relate to one another. These are the familiar gravity and electromagnetism and the less-familiar strong and weak nuclear forces.

All four work in the same way, each interaction is the result of an exchange. For instance, the electromagnetic interaction that holds all of matter together is the exchange of particles of light.

As far as everyday reality is concerned, the most important structural component of matter is the electron. Everything about sight, taste, smell, hearing and touch can be explained as a result of the behavior of electrons (except for sticking to the ground which is gravity at work).

Everything about the behavior of an electron is a result of its distinct tendency to emit or absorb particles of light. In classical physics this is called the 'charge' of the electron. (An accessible exposition of all this can be found in the slim volume, "QED: The Strange Theory of Light and Matter" by Richard P. Feynman, Princeton University Press, 1985.)

No one knows quite why electrons do this, but quantum mechanics has this tendency to 'couple' with particles of light quantified as the 'probability amplitude' of the electron. All the tremendous success of quantum mechanics is based on calculations using this probability amplitude.

The concept of a probability amplitude is a little subtle. In a very general sense, the probability amplitude is the cause of a probability. For example, the probability that two electrons will interact—actually exchange particles of light—is caused by the probability amplitude.

The way it works is: the probability amplitude is the cause of the probability; the probability is the cause of the exchange; the exchange is the relationship or interaction.

To a physicist, a probability amplitude and a probability are quite distinct. The difference between them is that while the probability amplitude is quantified by a 'complex number,' the probability is quantified by a 'real' number.

This is where the extra math reading came in handy.

Real and Imaginary

Mathematics recognizes three basic types of numbers: the real, the imaginary and the complex.

The real numbers are the regular numbers we use every day. They are based on the units 'plus one' and 'minus one' both of which, when multiplied by themselves, give 'plus one.' All of these are real numbers: 1, 2, -67, 0.6786, -1/3, pi, square root of 2, etc.

"Let's create," we can imagine some innovative mathematician thinking, "a whole new set of numbers based on different units, units which multiplied by themselves, do not give one but minus one."

Such numbers were called imaginary because, no matter how hard you try, you will never find a real number that gives minus one when squared. Mathematicians call the units of the imaginary numbers 'i' and '-i' both of which give minus one when squared. Examples of imaginary numbers are 5i, -1/2i, 0.76587i etc.

At first these imaginary numbers were fascinating toys for the 'pure' mathematicians to play around with in their Ivory Towers. In an unexpected demonstration of what Nobel Laureate and ICUS Founder's Award recipient Eugene Wigner called "the unreasonable effectiveness of mathematics in the natural sciences," it turned out that almost all the interesting equations of 20th century science contain these imaginary numbers.

The third type of number is simply(!) a combination of both; a complex number has both a real part and an imaginary part. Examples are (6 + 3i), (-4.578 - 1/3i), etc. In quantum physics, a probability amplitude or tendency to exchange is quantified by such complex numbers.

We can boil away the detail and state 'the tendency to get involved in a relationship is scientifically quantified by numbers that are not real.'

Probability

Back to the electron. It has a probability amplitude, a tendency to couple with particles of light. What happens when two electrons are in proximity? The tendency of electron one to give out light is matched by the tendency of electron two to take in light; the tendency of electron two to give out light is matched by the tendency

of electron one to take in light.

The calculation of the result of this overlapping of probability amplitudes is simple; you just square them. (Of interest only to those in the know: the 'square' is actually the marginally more interesting 'complex conjugate.') It just so happens that one of the remarkable properties of the 'square' of a complex number is that it is always a real number.

So the square of the probability amplitude is a real number, a number that gives the probability that an exchange will occur, the probability that a relationship will take place. The rule is, 'square the probability amplitude to get the probability.' A tendency to exchange—which is not real—converts into a probability that is real.

Revelation and Reality

Having understood this (and you're doing well if you've made it this far), I could, at last, see the correspondence between the Principle view and the viewpoint of the new physics. The answer had arrived.

Modern science has dropped the determinism of the eighteenth and nineteenth centuries and now puts probability in the causal role, probability is what makes everything happen in the material world. A real probability is the basis for something to actually happen, a real probability that a relationship will occur. Science says that before something can happen there must be a probability of it happening; the Principle says that before anything can happen a common base must be established.

Clearly the two concepts are talking about the same thing. Both probability and a common base are real, they are a part of the everyday world.

Science says that probability itself has a cause, a probability amplitude which, when multiplied by itself, gives the probability. The Principle states that a common base is the overlap—the plus and minus elements in common—of the Inherent Directive Nature or mind of something. Clearly the probability amplitude of science and the Inherent Directive Nature of the Principle are different words for the same thing.

Both a probability amplitude and the Inherent Directive Nature are something that is not 'real' in the sense of being a part of the material world. They are quantified not by real numbers but by complex numbers with an imaginary component. They are the cause, however, of the probability that things will interact.

Last of all, why do things have a tendency to exchange things in the first place. What is the cause of the probability amplitude? Science has nothing to say about this but the Principle says that the power of God, the Universal Prime Force, is the cause of this tendency of almost all things to exchange bits of themselves with other things. If all material was as aloof to exchange as the subatomic neutrino—which can fly through a trillion miles of lead with an excellent chance of not interacting even once—reality would be dull indeed.

We can only note, at this point, that the mathematicians have invented numbers far more imaginary than the ones we have mentioned so far, the hyperimaginary numbers. Perhaps these numbers could handle the Universal Prime Force.

Another interesting speculation is that the Principle states, without much elaboration, that the inherent directive nature of the minerals is the foundation for the simple mind of the cell; the simple mind of the cell is the foundation for the instinctual mind of the animal; the instinctual mind is the foundation for the consciousness of man.

Perhaps the hyperimaginary numbers of the pure mathematicians will one day find a role in quantifying aspects of the mind, perhaps even of the spirit.

But, for now, I have received enough slow-but-fine answer to satisfy my curiosity.

24. Certainty in Quantum Physics

I recently attended a delightful wedding ceremony in which a debonair Berkeley theologian and a beautiful Japanese businesswoman celebrated, for their church and non-church friends, their Blessing that occurred last August in Seoul. It was just like an enchanting episode right out of Life in the World Unseen. Perhaps the only little cloud in that blessed atmosphere was a philosophical friend of mine telling me that she had "stopped reading my columns [in the Unification News] because they were always about the same thing these days." Although a little crushed, I had to admit she was right; I had become a one-subject writer. My excuse was as follows: In 1981 (while witnessing in Las Vegas of all places) I had spent much time praying to understand what the Inherent Directive Nature in Chapter One of the Divine Principle was all about. As is often the case with such requests, not only was my answer almost a decade in coming but I didn't even realize that it had arrived until much later.

It is the progressive nature of that revelation (assuming that this is what it was) that my readers have had to endure—my monomania about what quantum physics is all about, It seems, however, that this is now complete—it certainly is to my satisfaction.

I decided that, before moving on to other areas of science, I would make an effort to share the insight with a larger audience than that of the Unification News. So I wrote the following and shipped it off to a few scientific journals. I wouldn't hold your breath while waiting to see it published in one of them, however, and, as the editor here is remarkable well disposed towards my columns, I am running it here first. It was written for a

technically-literate audience so, while I have done my best to 'keep it simple,' some parts might seem a little indigestible. As my esteemed philosophical friend has pointed out, however, I have gone over the ground in more detail and less jargon before so the best I can do is to refer you to the earlier columns.

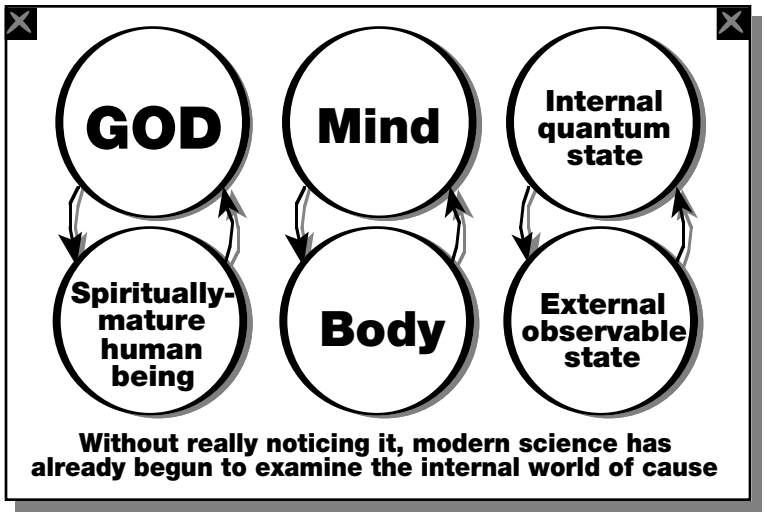
* * *

Here I will explore an interesting reformulation of the concepts recently discussed by John Maddox (*Uncertainty in quantum theory*, Nature **362** p. 693) that goes against "the general opinion that quantum mechanics is all about uncertainty."

In our democratic age there is a certain fondness for the rule of law; in being able to view the world as not being ruled by the capricious whim of God, the gods or any other above-the-law force of nature. This is embodied in the desire of all scientists to have (or, even better, be the one to develop) the tools that make their particular discipline *prescriptive*—such as is much of physics—rather than *descriptive*—as is still much of biology. In our age, all such 'meta-lawful' causal agents are about as palatable as our particular bête noire here in NYC—the parking-ticket-immune UN diplomat. This deference to lawfulness seems to have even infiltrated into the religious realm: my somewhat-unorthodox parish priest assured me once long ago, "Even God can't strike a match on jelly."

The scientific edifice founded on Newtonian determinism easily supported this expectation and, to a great extent, promoted the scientific effort by promising that there were laws out there to be discovered by the intrepid and lucky few.

It would seem perhaps as if modern physics has done away with all this by making irrelevant the concept of Natural Law. If indeterminism is *in* and determinism is *out*, wherefore the great laws to uncover? We are left, instead, with models which, while paralleling the way it all works, lack the satisfaction of telling us how it all *really* works. And, realistically speaking, if all you're learning in college is *modeling*, you might as well learn how to model the foreign-exchange markets and make a mint while you're at it.



Without really noticing it, modern science has already begun to examine the internal world of cause

There is a simple change in perceptual coordinates, however, that makes it possible to retain the concept of natural law along with all its benefits. For simplicity's sake I will refer here solely to the electron though the concepts apply equally to quarks, photons etc. and, by reverse reductionism, to all the structures made up of them.

Four frameshifts

Shift one: *The electron has an internal and an external extension and both are equally real*. Even though we have recently come to understand that the vacuum is not just a simple absence of matter/energy and, as Einstein revealed, that the common-sense perceptions of spatial and temporal extension are just relative projections of an underlying invariant reality; there has been a reluctance in some quarters to accept the quantum state of the electron as being *real*.. There is actually no reason (other than a philosophical preference) against accepting the probability amplitude—the little arrows of Feynman's sum-over-all-histories method—as actually 'pointing' in an internal dimension that is as real as is the external dimensions of space and time. Of course, we have no idea what this internal dimension actually *is;* but then, to be honest, we have no firmly-established idea of what a space or a time dimension is either so this is not really a compelling objection.

Shift two: *The Natural Laws that govern the electron influence the internal extension; there are no laws at work on the external extension*. A moments thought allows this as eminently reasonable: while modern science embraces no declaration as to what a law actually *is*, a law is certainly more abstract and internal than substantial and external. Just as in the classical case, the laws are deterministic but now only determine the history and development of the internal extension. As Maddox put it, "For the Schrödinger equation [that describes the development of the internal state] is a perfectly deterministic equation exactly comparable to the equation of motion of a classical mechanical system."

The difference, then, between classical and modern physics is not so much that of determinism versus indeterminism but rather that of externally- and internally-acting natural law. By implication, there is no such thing as an externally-acting natural law (at least for things made of electrons); all the laws of nature act internally.

These natural laws that govern the electron (in current understanding, at least) are succinctly described by an action equation which can be thought of simply as a measure of the influence of interaction. In this sense, all natural laws deal with interaction.

Shift three: *The objective state of the electron is its internal extension; the state is external only during interaction.*

An axiom of the scientific method is that there is an objective reality *out there* for us to explore and comprehend. In the classical view this objective reality is the external extension. Unfortunately for this view, it is in complete disagreement with experiment—while the internal state of the electron is continuous and clearly defined at all times, the external state is only clearly defined during an interaction. Rather than contort ourselves trying to fit this into the classical mold it is much simpler to bite the bullet and accept this at face value.

The internal extension (like the complex numbers used to describe it) does not obey the Law of the Excluded Middle (LotEM)—there is no problem having an internal state be a supposition of seemingly mutually-contradictory states. (*If* I were a sexist, I would probably at this point make a snide remark about women having no problem at all comprehending this.) Interaction, on the other hand, involves the external extension—it is the electron coupling with subsystems from within its virtual 'quantum foam' structure. Interaction is external and does obey the LotEM: a photon was exchanged, the W^- was emitted, etc. In order to couple the electron must be in an external state and these are never suppositions of mutually-exclusive ones. The difference between the subtlety of the internal state and the simplicity of the external is exactly described by the difference between the complex and the real numbers.

Early classical science equated the objective reality with the spatial extension with its observable projections as width, height and depth interconnected by the Pythagorean relation between x^2, y^2 and z^2. While rotational movement altered the particular projection, the size was objectively invariant.

The work of Einstein and Minkowski expanded this classical concept into a much more sophisticated one where the invariant objective reality became the worldline with its observable projections in space and time connected by a relation between t^2, x^2, y^2 and z^2. While it is linear motion, in this case, that alters the particular projection as space or time, the worldline itself was invariant.

Quantum mechanics has taken this one step further; the projections of the invariant objective reality are now based on the movement through time. While the classical worldline was sufficient to describe the past, it is sorely lacking when dealing with the future. The future of the electron is not a single worldline, rather it is a set of possible worldlines each with its probability of happening; objective reality in quantum mechanics has observable projections connected by a relation on ψ^2, t^2, x^2, y^2 and z^2 (where ψ is the wavefunction; the description of the internal extension).

This shift in viewpoint has two attractive advantages: It retains objective reality and it retains just one of them. For in this interpretation of the quantum formulation we do not have to lead Schrödinger's cat afloat in the realm of the undead as it is either dead or alive since the atomic nucleus did, or did, not emit one of its subsystems irrespective of whether the experimenter remembered to look in the box or not. Neither do we have to grapple with the concept of the universe intoxicatingly cloning itself at a rate to put yeast in warm grape juice to shame.

Shift Four: *The electron is autonomous in the external projection of its internal state.* This is the indeterminism that so rudely intruded into the conceptual simplicity of classical science—there seems to be nothing in the "collapse of the wavefunction" that makes the electron pick one possible state over another. To be sure it usually picks a more probably state, but occasionally it will pick a less probable one. Rather than struggle to squeeze this into the concept that there *must* be something making it happen (the observer, some have speculated) is much simpler to take things at face value and accept that there is nothing in the universe that determines which, of the many possible, external states an electron will interact in. This is to be expected since the collapse involves the externals and does not have—see above—any natural law regulating it.

To call this "indeterminism" is to take the somewhat politically-incorrect viewpoint of the observer who does not know which history the electron will follow. From the point of view of the electron, however, it would make more sense to call this is a simple kind of autonomy. While raising many questions, such a view does solve one of the thorny problems of classical science: in a deterministic universe why do so many people carry around the concept that they have free will? Some are even of the opinion that plants and animals exhibit a somewhat milder version of it.

One rather stimulating aspect of this concept is that it has the potential to rile both sides of the science v. religion debate. It is certainly anathema to those who believe that "God knows everything." To suggest that omniscience does not even encompass the future of a single electron will be hard to digest indeed. And just as the mathematicians have had to eat humble pie and recognize that there will always be some theorems that are undecidable in even the most sophisticated of constructs; so we scientists might have to accept that if God doesn't know the destiny of an electron for sure (though we can be confident that He has a good idea of the probabilities involved), then we cannot either.

A new framework

Together, these four simple perspective shifts, while fully in concordance with the experimental facts, create a view of the world that some might consider quite opposite to the scientific worldview. Stripped of its technical jargon, we can paraphrase all that has preceded as: The electron has two aspects; one that is internal and abstract, the other that is external and (relatively) tangible. The abstract side is influenced by natural law and, in its turn, influences what happens to the tangible aspect. As we are used to calling the autonomous, abstract aspect of a system that runs things its "mind" we can—with a lot of reservations, to be sure—call these two aspects the "mind" and the "body" of the electron. With this established, we can, with similar reservations, equate the

abstract orbital of an atom with its “mind” and the orbiting electrons the expression, or “body” of the atom. The implications for the more sophisticated constructs, especially the living ones, are fascinating but—in that often used excuse—I have no space to explore them here.

With an appropriate dose of humility, however, we can correct two of the Greats: Decartes established dualism on a poor foundation we see; the difference between ‘mind’ stuff and ‘matter’ stuff is not extension—they both have it—but that one is internal and the other is external. And Einstein will have to capitulate at last; not only does God play dice with the Universe, His dice have a mind of their own!

25. The Search for Beauty in Modern Physics

I once received a letter that was delightfully encouraging about my science writing. After a health dose of flattery, my correspondent recalled a German book from her youth—"In The Beginning There Was Water"—that made science very accessible to the lay reader. As she is home-schooling her 6 year old she wanted to make similar material available to him and asked, "Is there such literature in English?"

My first impulse was to tell her about Isaac Asimov who has written (literally) hundreds of books, many of which make science extremely accessible to any reader. In fact, when I was a teenager and fascinated by science I used to devour his books as if they were the morning's fresh manna.

Downright Resentment

My second impulse, however, was not to tell her about Isaac Asimov. The problem with all his books is that they are steeped in atheism often with a tinge of downright resentment towards God. Now most of the time, of course, this is not a problem and his explanations are 'neutral' in the sense that there is no God or anti-God sentiment there. But, whenever there is a chance to score a point for atheism, he is liable to make it.

Science holds such a lofty position in our culture that such a one-sided presentation is liable to be very unsettling to a youngster being brought up in a religious household. Especially so if the parents are scientifically unsophisticated and unable to answer the questions raised by the sophisticated Dr. Asimov.

The best I could do for my correspondent was to recommend his writings with the above stated reservations.

Keeping the Faith

Isaac, unfortunately, is not alone. All too often, the intellectual outlook of a scientist is that of an atheist. With this in mind, you can imagine my delight on reading a book that explains for the general reader the most recent developments in modern physics. Unlike Isaac, here God is explicitly recognized—and appreciated no less—throughout the discussion.

This book which I highly recommend (although it is a little too advanced for 6-year olds) is "Fearful Symmetry: The Search for Beauty in Modern Physics" by Anthony Zee, Professor of Theoretical Physics at the University of California. (Macmillan Publishers, New York. 1986)

Dr. Zee is a disciple of Albert Einstein, following faithfully his admonition that, "I want to know how God created this world. I am not interested in this or that phenomenon. I want to know His thoughts, the rest are details."

Dr. Zee brings a perspective to bear on the history of twentieth-century physics that appears quite unique to me (although I cannot claim to have made an exhaustive study of the subject.) He sees all the remarkable advances in physics as occurring in one of two camps—the pragmatists who are "interested in this or that phenomenon" and the theorists who are more interested in the mathematical structure underpinning the reality we perceive. This mathematical structure Dr. Zee equates with "God's thoughts."

Einstein and his intellectual heirs (and Dr. Zee is proud to count himself among them) are convinced that this fundamental mathematical structure is going to have certain qualities.

Dr. Zee quotes from the memoirs of Dr. Bondi, a contemporary of Einstein. "I put down a suggestion that seemed to me cogent and reasonable. Einstein did not in the least contest this, but only said, 'Oh, how ugly.' ... He was quite convinced that beauty was a guiding principle in the search for important results in theoretical physics."

Simple and Beautiful

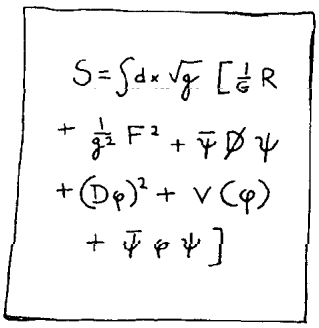
Physicists are normal people, perhaps just a little more curious about the material world. Along with everyone else, Dr. Zee explains, we "wake to find ourselves in a strangely beautiful universe. The sheer wealth and splendor of physical phenomena never fail to astonish us. As physics progressed, physicists discovered that the diversity of phenomena did not require a diversity of explanations. In this century physicists have become increasingly ambitious. ... No longer content to explain this phenomena or that, they have become imbued with the faith that Nature has an underlying design of beautiful simplicity."

Simplicity is the easier of the two to define. Dr. Zee declares that, "Contemporary physics rests on the cornerstone of reductionism. As we delve deeper, Nature appears ever simpler. That this is so is, in fact, astonishing. We have no a priori reason to expect the universe, with its fantastic wealth of bewilderingly complex phenomena, to be governed ultimately by a few simple rules."

Beauty is a little more subtle to pin down. Dr. Zee makes a lucid attempt. "In everyday experience our perception of beauty is tied to the psychological, the cultural, the social, and, often even the biological. Evidently, that kind of beauty does not lie at the heart of physics. The beauty that Nature has revealed to the physicist in Her laws is a beauty of design, a beauty that recalls, to some extent, the beauty of classical architecture, with its emphasis on geometry and symmetry. So, "following the ancient Greeks ... I will continue to equate symmetry with beauty." To Einstein and his intellectual heirs, symmetry is the ultimate beauty.

Naturally, the physicists do not leave things as simple as this. "The precise mathematical definition of symmetry involves the notion of invariance. A geometrical figure is said to be symmetric under certain operations if those operations leave it unchanged. For example, the circle is left invariant by rotations about its center." It is the sophisticated development of this simple idea that has generated many of the most spectacular advances in contemporary physics.

Incidentally, Einstein, who made many of his great contributions using this concept, apparently rued the day when he summed his work under 'relativity' (with its social implications of 'anything goes') instead of the more accurate 'invariance' (when only certain things 'go').



This then is the "faith that has sustained" the theoretical physicist, the belief and the search for a theory of beauty and simplicity that would fulfill the "dream of writing down the design of the universe on a piece of table napkin." To some extent this goal imbued with hubris has been accomplished. The illustration taken from the book shows how far they have already come, the whole universe in an amazingly compact description. Be forewarned, however, because "to understand what each symbol means one would have to spend years in a reputable graduate school." It's not that simple!

Not enough

Succinct though this formulation might seem, it is not sufficient for the modern-day physicist, it is still too complicated. It is the sophisticated application of the concept of symmetry that has allowed the physicist to progress even this far, and it is the concept of symmetry that shows the greatest promise of further deepening our understanding.

Einstein was the first to really make great strides using this concept. Then came a decades reign for the pragmatists as the particle physicists discovered a plethora of sub-atomic particles that seemed so very, very different from each other. In recent years, however, much to Dr. Zee's delight, the beauty-seekers have been the ones to pioneer the way and make the advances. Pursuing purely mathematical concepts of 'group symmetry' they have gone before the pragmatists, suggesting the existence of certain particles and pointing out where to look for—and in a remarkable number of cases to find—them.

Broken Symmetry

One of the keys to understanding how symmetry can be applied to particles so different to one another is 'symmetry breaking." What starts out symmetrical does not necessarily end up symmetrical. For instance, a ball dropping onto the center of a roulette wheel is a symmetrical situation. When the wheel stops, however, a clear asymmetry is present, the ball is in one slot and not the one you put your money on.

The most up-to-date understanding declares that the universe was totally symmetric in the very beginning when everything was super hot and had loads and loads of energy. As the universe expanded and cooled, however, asymmetries appeared (such as matter, a "one part in ten billion contamination in an otherwise pristine universe). During this symmetry breaking, for example, the interaction responsible for light in all its abundance ended up being carried by a massless particle while other interactions (which if they occurred would dissolve matter as we know it) were carried by particles so massive they have very little chance of ever getting off the ground. As Dr. Zee so picturesquely puts it:

"We see how clever the Ultimate Designer is. He wants grand unification, but he arranges for the [strength of the interactions to change] very slowly so that they meet at an extremely high energy. While the neutron decays in about 10 minutes, the proton lives on beyond the eons. It would not be fun to create a universe that lasts only 10 minutes! While the [particle of light] blithely dances, the hopelessly overweight [particles responsible for the proton decay] groan. Sorry, says the Boss, I have to keep you two overweight so that My universe can last for a while!"

Who said physicists have to be atheistic? I just wish dear old Isaac would have a change of heart, he really does have the knack of making the wonders of the creation available to all. He just will not pay honor to where honor is due.

26. THE THREE FAMILIES OF MATTER

Most children, if not all (especially boys), eventually get an overwhelming urge to pull something apart and find out what's inside and how it works. While this impulse might fade in some, for a certain type scientists it ripens into the relentless smashing of the atom into smaller and smaller components with the same goal in mind: what's inside and how does it work.

The closing months of the last decade established yet another milestone in this quest with an announcement at a press conference from the Stanford Linear Accelerator Center (SLAC) in California on October 12 upstaging the European Center for Particle Physics (CERN) in Geneva which planned to go public with the same findings on October 13.

The historic pronouncement was that they had firmly established that there are only three fundamental families of subatomic matter particles. This is a welcome achievement because, before October 12, there seemed to be no limit to how many families there might be, a frustrating thought for those looking for simplicity.

This accomplishment, of course, is just the latest step in a long search that—while people have theorized about what the world is made of from time immemorial—can only be considered to have been carried out on the firm foundation of experiment since the nineteenth century. An overview of this history will help in the explanation of what the two teams accomplished. If, however, you already feel at home with quarks, leptons, neutrinos and the like, this historical overview can be passed over without injury.

History of Smashing Matter

It was John Dalton, a weaver's son in the north of Britain, who, just 182 years ago, replaced the alchemical mysteries with the atomic theory of matter in his A New System of Chemical Philosophy published in 1808. It took awhile for atoms to be established as the ubiquitous, ultimate components of matter, as the evidence, though accumulatively indisputable, was always indirect. It is only within the last decade that we have been able to devise techniques to 'see' atoms directly.

Once established, however, the atom—its name derived from the Greek for "cannot be cut"—reigned for almost a century as the indivisible, unchangeable stuff of the material world.

In 1897, J. J. Thompson of Cambridge University dethroned the pretender with his discovery of the electron, an electrically charged fragment torn out of the 'cannot be cut' atom (though it kept the name.)

As atoms are electrically neutral, Thompson speculated that electrons in an atom were like 'negative raisins dispersed in a positive pudding.' Experiments by Ernest Rutherford at Manchester University, however, clearly demonstrated in 1911 that the positive charge of the atom was concentrated in a nucleus that was thousands of times smaller than the atoms themselves. The culinary analogy was replaced by the astronomical: planetary electrons in orbit about a solar nucleus.

In 1914 Rutherford isolated the positive particle from the atomic nucleus and named it the proton. It was over 1800 times as massive as the electron but had exactly the opposite electric charge.

In 1928 Paul Dirac at Cambridge University found two solutions to the quantum equations describing the electron. One solution matched the electron found in regular matter, the other, he proposed, was the 'antimatter' equivalent. This particle, the positron, was observed in 1932. It was found that every particle has its antimatter counterpart so, in the following discussion, you can assume that every particle mentioned has its anti-matter counterpart. When matter and antimatter meet they annihilate each other, turning into energy. This is why anti-matter cannot exist in nature for long (cosmic rays hitting the upper atmosphere do produce a little but it quickly gets annihilated) and is just a laboratory curiosity.

Prompted by reports of a mysterious radiation by German physicists, James Chadwick found in 1932 yet another component of the atomic nucleus, the neutron, a particle just a fraction heavier than a proton and with no electric charge. Only hydrogen, with just one electron and proton, has no neutrons. They contribute to the stability of the nucleus and the larger the nucleus, the more neutrons needed for stability. Uranium, with the largest nucleus found naturally, needs 146 or so to keep its 92 protons in order—and even so, as we are all too aware, uranium is not all that stable. By the way, when people talk of 'splitting the atoms' they are actually discussing the splitting of the atomic nucleus—splitting off the electrons from the atom is relatively easy.

While a neutron is quite stable within an atomic nucleus, in isolation it falls apart in about 10 minutes into seemingly just a proton and an electron. It was the close study of this breakup that led to the discovery of the fourth, and last, of the 'regular' particles, the neutrino. Wolfgang Pauli insisted in 1930 that the neutrino must exist if we wanted to retain the Law of the Conservation of Mass and Energy in the decay of the neutron. As everybody did, it was quickly agreed that the it actually fell apart into a proton, an electron and an unobservable neutrino. It took until 1956 until this ghost particle was detected by Clyde Cowan Jr. and Frederick Reines.

This particle, with no detectable mass and no electric charge, is so utterly indifferent to interaction with matter that it can enter a trillion miles of steel with an excellent chance of coming out the other side. As you might expect, such aloofness makes them fiendishly difficult to detect. But they are everywhere, our sun is such a copious producer of neutrinos that 20 billion or so pass through our bodies every second—night and day as the earth is as transparent as the vacuum to them.

By the mid 1930s it looked as if the answer was in: There were just four ultimate bits of matter, the electron,

proton, neutron and elusive neutrino.

This satisfactorily simple answer barely survived the next decade.

In the 50s, first with experiments with the creations of cosmic rays and then with high-energy particle accelerators (atom smashers) more and more 'elementary,' if unstable, particles were found until, by the 1960s, there were literally hundreds of them, the aptly named 'particle zoo.' It was a time of doubt and confusion that ended in 1964 when theorists Murray Gell-Mann and George Zweig of Caltech showed that the entire zoo could be accounted for if the proton and neutron were composite particles made of triplets of two fundamental particles puckishly named the U (for up) and the heavier D (for down) quarks. The names are pure whimsy, and, as we shall see, get even more so.

The proton is UUD and the neutron UDD and, as the U is only about 8, and the D 16, times more massive than the electron, most of the 1800 mass of the proton is the energy—equivalent according to Einstein—binding the quarks together. This energy comes from the strong nuclear force and quarks, and the composite particles constructed from them, are called hadrons (from the Greek for strong). The electrons and neutrinos which do not 'feel' this strong force are called leptons (from the Greek for lightweight).

Quarks have two unusual aspects: they have a fractional electrical charge and theory predicts the impossibility of ever seeing an isolated quark—though the indirect evidence is such that they are now firmly part of the accepted Standard Model.

But for one flaw, it seemed that once again the universe was again a combination of the comfortable number of just four basic constituents:

	Particle	Mass	Electric Charge
Leptons	electron	1	- 1
	neutrino	0	0
Hadrons	D quark	≈ 16	- 1/3
	U quark	≈ 8	+ 2/3

These particles seem to be the true 'atoms', the 'cannot be cut' elementary building blocks out of which the universe is constructed. They are truly tiny: one trillion trillionth the size of a human being and one hundred millionth of the merely tiny atom.

Families of Particles

This simplicity, however, had an unavoidable flaw, there were particles that just didn't fit into this scheme of things. The first of these misfits to be found were the muons. These are constantly being created by cosmic rays crashing into the upper atmosphere and were first detected in 1935 by Carl Anderson and Seth Neddermeyer who were looking for a quite different particle on the summit of Pikes Peak in Colorado.

The muon behaves just like an electron that is 206 times more massive. It did not fit into the scheme of things, and it caused the eminent experimenter Isidor Rabi to ask the famous question that still remains unanswered, "Who ordered that?"

The neutrino mentioned earlier is actually more properly called an electron neutrino. It is associated with the creation (and destruction) of the electron, such as in the aforementioned decay of the isolated neutron. The muon also has its buddy at birth and death, the muon neutrino. The electron and muon neutrinos are experimentally quite different although the lack of good ideas as to exactly what the difference is between particles described by negatives—no detectable mass, no electric charge—is a clear sign that all the answers are not in yet.

A third, 3,000 as massive, relative to the electron, the tau, was discovered in the mid 1970s, and, as expected, had its unique partner, the tau neutrino. This brought the number of leptons to six, two in each of three families.

The quarks had cousins too. In the particle zoo of the fifties were particles that behaved so strangely that they were called strange. The quark concept explained them nicely, they contained a third type of quark called the S (for strange). This quark was a cousin to the D with the same fractional charge of -1/3 but nineteen times heavier. In the late 1960s yet another quark was shown to be theoretically necessary, the heavier cousin of the U, called the C (for charm) quark. It was found experimentally in 1974 and was 300 times heavier than its U sibling.

In the 80s, good evidence was accumulated for yet another set of cousins that were much heavier still. Particles containing the B (for beauty, originally, but now, as whimsy has limits even in physics, for bottom) quark have been detected and, although it has yet to be pinned down, everyone believes in the existence of the T (for truth, now top) quark. This also brought the number of hadrons to six, two in each of three families.

Rabi's exasperated question can now be updated to, "Why is He repeating Himself?" As far as we are aware, the universe would function quite normally without the muon and tau families. No one knows why they are there, though most expect that they have, or had, some role to play. For instance, many cosmologists think the number of neutrino families played a crucial role in the early expansion of the universe after the Big Bang, moderating it so that it was not too fast—no chance for galaxies, suns and planets to form—or too slow—gravity collapses everything back into a Big Crunch.

So this is the current lineup of the three families, a monument to how far scientists have come in understanding the particles of matter. Hopefully without adding too much confusion at this point, I should mention that these 'particles' are as much waves as bits of anything—waves, it seems, in something really exotic like 'space-time' or 'hyperspace.' But, for our purpose, there is no harm in continuing to think of them as 'bits of matter.'

		Found in regular matter	Found only in cosmic rays and high energy experiments	
	charge	1st family	2nd family	3rd family
hadrons	-1/3	Down quark	Strange quark (x19)	Bottom quark (x590)
	+2/3	Up quark	Charm quark (x300)	Top quark (≈ x10,000)
leptons	1	electron	muon (x206)	tau (x3,490)
	0	e. neutrino	m. neutrino (?)	t. neutrino (?)

The Three Families of Matter (with the mass relative to the member in the first family in parenthesis.)

We have now arrived at the question just recently solved. Settling the question of just how many of these families there are has long been a major question. No theory has delimited the number of possible families, so only experiment could provide answers, but, until recently the equipment needed to perform such explorations was beyond our technological prowess.

Fermions and Bosons

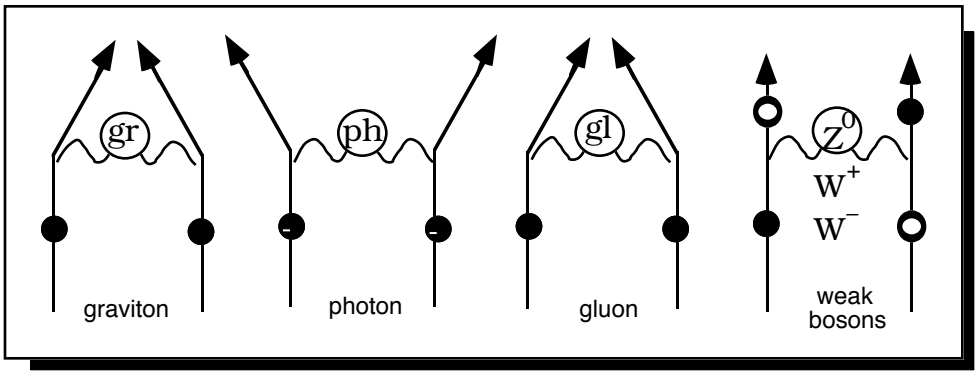
The answer to this question, it was long realized, could be provided by examining the decay of a fundamental particle known as the Z0 (zee naught) boson. Now if you've managed to keep track, you will immediately realize that this is not one of the particles we have already cataloged. This is because all the particles we have discussed so far are 'bits of matter,' a class of particle physicists call 'fermions.' There is, however, another class of particles that are not 'bits of matter,' called bosons and the Z is one of these. Fermions are the currently accepted explanation of the existence of matter while bosons are the currently accepted explanation of its interactions—if fermions are the bricks then bosons are the mortar.

The most recent and sophisticated developments of quantum theory suggest that these two types of particles were actually one at the moment the universe was created but that they irrevocable parted company a trillionth trillionth trillionth of a second later.

The theories in the early days of modern science relied on a rather troubling concept, 'action at a distance.' Gravity, electric and magnetic forces were all supposed to have their effect by invisible, intangible forces—and scientists were no happier in those days than they are now with intangible, invisible things.

The development of quantum physics, however, solved this problem. The breakthrough happened first with electromagnetism. Everything known about electric and magnetic forces was revealed to be the result of the exchange of particles called photons between matter particles (the fermions.) Photons are not exotic, they are as commonplace as turning on a light switch and flooding a room with light as photons are the tiny 'bits' that light (and radio waves and X rays etc.) are made of.

To put it simply, photons are the 'carrier' or boson of the electromagnetic force. In human terms, such trafficking can be liked to the prodigious mailing of Christmas cards that occurs every year. The cards are the bosons, the people are the fermions. The exchange of cards can maintain a relationship (even if a minimal one) with distant relations, friends and acquaintances over many years.



The four fundamental forces of nature are actually the matter particles (fermions) exchanging carrier particles (bosons): the bosons are the graviton in gravity, the photon in electromagnetism; the gluon in the strong nuclear force, and the vector bosons in the weak force.

Before too long all the forces of nature were removed from the 'action at a distance' camp and seen to occur by the exchange of bosons. Scientists had already realized that all the forces or interactions experienced by matter could be reduced down to just four basic ones, and that each of them had its carrier boson particle. These are:

Gravity: All the fermion matter particles experience this although, on a single particle level it is so infinitesimal as to be routinely ignored. While it is extraordinarily weak it is accumulative so that a huge numbers of matter particles, such as the earth, have an appreciable effect—though easily overcome by a toy magnet. Gravity structures the planets, suns, galaxies, superclusters etc. The boson carrier particle of gravity is the (still hypothetical) graviton which has no mass and has an infinite range.

Electromagnetism: Only charged particles experience this. It is a trillion trillion trillion times stronger than gravity but, as plus and minus cancel out, electric forces are not accumulative. It is electric forces that structure atoms, molecules and living systems such as ourselves. The boson carrier particle of this force is the photon of light which is massless and has an infinite range—just look at a star to verify this.

The strong nuclear force: Only hadrons (quarks and their composites) experience this. It is hundreds of times stronger than electromagnetism and is responsible for the structuring of quarks into particles and their structuring into atomic nuclei. The boson carrier of this force is the gluon which, like the quark, is impossible to isolate in a free state. Gluons experience the strong force and can only travel distances on the scale of the atomic nucleus which is why the effect of the strong force is limited to within the nucleus.

The weak nuclear force: All the fermion bits of matter experience this force. It is much weaker than electromagnetism (though still a superhero in relation to effete gravity.) It is not so much responsible for structuring things as for their breakup—the breakup of the isolated neutron is the weak force at work. The boson carriers of this force are called 'intermediate vector bosons' and there are three of them, two charged and one uncharged: the W+, the W- and the Z. This last is the particle holding the answer to the number of matter particle families.

Incidentally, it is not just the numerologists who believe there must be something behind the numerical coincidence of four types of fermion matter particles and four types of boson carrier particles, it is also one of the hot topics of theoretical physics.

Practical applications

Practical applications could emerge from this esoteric subatomic particle research. Mating two realms of the arcane, Nobel laureate Luis Alvarez has already used the low energy muons from cosmic rays to 'X ray' the Pyramid of Chephren to see if there were hidden chambers waiting to be discovered. There were none.

The muon can take the place of an electron in an atom and, as it is so much more massive, circles much closer to, sometimes even within, the atomic nucleus. Muonic hydrogen, being so much more compact than regular 'electronic' hydrogen, has little problem in getting close enough together to fuse, a potential portal to the potentially unlimited energy resource of hydrogen fusion (comforting in case the fusion-in-a-Utah-test-tube fails to deliver.) The barrier on this route to an energy utopia is the one great difference between the electron and muon. Unlike its stable cousin, the overweight muon is unstable and slims down in about 2 microseconds into an electron before it has a chance to make much happen. This is still an active area of research and, as history attests, breakthroughs can happen suddenly.

The Z factories

It had been realized some time ago that if the Z could only be made in sufficient quantity the question of the number of families could be answered just by looking at the statistics of the way the Z fell apart into other particles, its decay. The reasoning behind this is subtle, but it can be simply outlined. The Z can decay into just about any other particle as long as they are less massive than the Z. All the neutrinos have masses too small to detect so they are all potential end products. Every family of particles has a neutrino member, so the more families there are, the more ways there are for the Z to fall apart into neutrinos—just as more holes in a bucket will empty it faster. Find the number of ways the Z can fall apart into neutrinos and you have, by implication, found the number of families as well.

The trick is to make the Zs.

The basic idea is simple, put enough energy in a small enough space and the particle will be produced. This is the function of the high-energy accelerators. A particle and its antiparticle are boosted to high speed by radio waves and allowed to smash into each other. The energy of the matter-antimatter annihilation plus the energy of the speeding particle's motion is all available to incarnate as a new particle. The mass of the Z is about 90 billion electron volts, which, while tiny by regular standards is almost a hundred times the mass of a proton, making it the largest 'elementary' particle on record.

The key to the experiment is measuring how many Zs are produced as the energy of the colliding beams changes. The formation and decay of the Z is a resonant phenomena, so the number of particles produced rises as the energy rises, reaches a maximum and then falls off at higher energies. The scientist draws a graph: the number of Zs produced as the energy of the beams rises.

While the 'easiest' way to get the high energies needed to make Zs is to use heavy particles such as protons and anti-protons, the results are very messy and difficult to interpret—they are 'bags' of quarks so its difficult to tell what's hitting what. This is why both the American and European teams looked to electron-positron colliders. They both use radio to boost the particles energy but utilize quite different designs.

The European machine is directed by Dr. Carlo Rubbia who earned the Nobel Prize for his discovery of the Z

in 1983. Called the Large Electron-Positron (LEP) accelerator it was completed last July at a cost of about $1 billion put up by 14 western European governments. CERN must get a whopping electric bill, the machine draws 200 megawatts—2 million light bulbs—when turned up to full power. LEP is housed in a tunnel 17 miles long straddling the border of France and Switzerland near Geneva. The beams of electrons and positrons circle in opposite directions, gaining energy until magnets slightly deflect their path so that the beams cross, matter-antimatter annihilation occurs and the Z is produced. This is a real Z factory, by the end of last year data had been accumulated on over 100,000 Zs.

The Stanford Linear Collider, under director Dr. Burton Richter, is a new development of an old technology, a linear accelerator that only cost $115 million to develop. About 50 billion electrons and positrons in separate bunches about 30 yards apart race down a long straight track where they are separated and diverted into two opposite curved tracks resembling the claws of a tongs. At the center of the tongs they collide, annihilate and create the Z —no mean feat as the specifications call for the beams a tenth the size of a human hair to meet after zipping almost at the speed of light down the four-mile track, at a task likened to firing two guns at each other from 100 miles apart and getting the bullets to hit. As it only takes the particles about a millionth of a second to get from the start of the track to the collision point, there is plenty of time to repeat the process, the goal is 120 times a second.

Naturally, one just doesn't stand with a click counter at the point of annihilation and count the Zs as they appear: the detectors of the Zs are at least as awesome as the machines themselves.

The CERN setup now has four points in the ring where the beams collide and the Zs are produced each with a different detector: hangars filled with huge machines that would look quite at home in an Industrial Light and Magic special effects lot. These are built and operated by large teams of scientists—when the teams publish their results their papers are signed by 278, 374, 486 and 559 authors! The US government actually helped fund the construction of the largest detector, L3, a leviathan 8,000 tons of engineering. Apparently other spots are available—if you need Zs and have $100 million or so to spare, get in touch with Dr. Rubbia.

The Stanford set up, of course, has only one point of intersection where the electron and positron beams can collide. At the point of collision sits the Mark II detector which, like its European cousins, is run by a large team of 130 scientists (and presumably a host of technicians).

When a Z forms, it quickly disintegrates into a shower of subatomic debris which collide with atoms in the detectors and stimulating electronic sensors—for this is not the romance of the cloud chamber with its beautiful spidery tracks, it is torrents of electronic signals being processed by huge computer banks into printouts and pictures on television screens.

On October 12 the Stanford group was the first to announce their analysis of the statistics of the Z resonance curve, the number of families is 2.8 ± 0.6 based on measuring 500 Z particles, the range of uncertainty coming from a variety of sources including the very nature of a statistical analysis. As there can only be a whole number of families there must be only three of them.

The four European teams, prompted by Stanford's, made their announcement later that day, 3.42±0.48, 3.27±0.3, 3.12 ±0.42 and 2.4±0.65 based on a total of 11,000 particles and giving the same result, three families. Because of the much larger number of particles involved, the European results are statistically much more sound.

Though the Stanford group were aware of the upcoming announcement from CERN they denied rushing theirs into press so they would be not be overshadowed by the much more significant announcement from Geneva. No matter, it will probably be Nobel Prizes all round—a fragment for each of the thousands involved—as those few hours will hardly count when it comes to honoring the accomplishment of both teams.

This is but a milestone on the road to coaxing the universe to yield up its secrets. The end is no where in sight, scientist want to build yet more powerful machines, such as the Superconducting Super Collider planned for Texas, to dig down even deeper. No one can tell if all this will one day lead to a technological leap that will transform our lives in the way that electricity and the computer have. It might, it might not.

For the scientist, however, there is tremendous satisfaction in cracking it all open and finding out just What's Inside? and How does it Work?

27. THE QUANTUM MECHANICAL WORD OF GOD

Like many an American, I have many horror stories to tell of the Post Office's reluctance to deliver the mail. So I was pleasantly surprised when my copy of the epochal May *Unification News* appeared in my apartment's mail box just two—not the usual three to five—weeks after they were mailed at the Newark post office. I read it over dinner. If I say so myself, it was our best issue yet. My pleasure, however, was a little dimmed as I read my column and realized that, while it was accurate, the 'forest' got a little obscured by the 'trees.' This month I shall try not to lumber you with too many details.

Not so long ago, science and religion were clearly enemies bent on mutual subversion. Almost unnoticed, there has been a Romeo-and-Juliet style rapprochement between them brought about by two of their twentieth century offspring, quantum physics and the Divine Principle, which have remarkably similar concepts as to what makes the universe function the way it does.

Divine Principle (DP) and Quantum Mechanics (QM) have their differences, but they are mainly in the

descriptive techniques used. While religion is restricted to the inherent impreciseness of words, science suffers no such limitation, as its descriptions are couched in the utter preciseness of mathematical symbols. Thus, while it might be difficult to tell if the English translation of the Korean DP is *exactly* what Rev. Moon meant, the communication of concepts in science suffers no such ambiguity: Newton's 'F = ma' means precisely the same thing to a Russian scientist as it does to an English one.

Taking into account the different methods of description, however, we will see that DP and QM articulate the same concepts. In this article I will outline the scientific description of what DP calls the 'common base,' the 'inherent directive nature' (both explored in 'tree' detail last month), and the 'Logos' or 'Word.'

We can start with the basic point of agreement between DP and QM:

1. Relationship

All things are composed of relationship; both agree that everything is caused by, or is the result of, some sort of relationship.

DP magisterially states that all existence, action and multiplication is the result of relationship. That covers just about everything.

QM agrees, except that scientists use the word 'interaction' rather than 'relationship.' One of the great marvels of modern science is that it explains all the apparent complexity of the universe as subtle variation-and-theme on just four interactions—the commonplace electric and gravitational and the less-familiar two at work inside the atom. (You will probably not be surprised that theoretical speculation and experimental evidence are accumulating that the four are actually echoes of just one.)

The consensus is that everything is caused by relationship, interaction.

2. Exchange

Both DP and QM agree on the cause of interaction: interaction is the result of an exchange.

In the Divine Principle, the concept of give-and-take action is absolutely fundamental. Be it a molecule, a family or an experience with God, in every case the relationship involves an exchange of something—electrons, milk and cookies, or that spiritual enigma, love.

Quantum physics is less catholic in its explicit claims (although there is the implicit assumption that, as physics is the foundation of the rest of science, even the most sophisticated states of matter such as the brain are just 'intricate biochemistry,' which is just 'intricate physics'). QM contents itself with the pronouncement that the four fundamental interactions are the result of the exchange (physicists tend to use the slightly odd term 'coupling') of four different particles: one of them familiar—the bits of light involved in electricity—two of them observable in the subatomic realm with billion-dollar 'atom smashers,' and one that 'just has to be there,' in the case of gravity.

The consensus is that everything is caused by relationship which is the result of an exchange (give-and-take, coupling).

3. Probability

Both QM and DP go one step further and agree that there is a cause to the exchange.

In DP the cause of exchange is called the 'common base.' DP, as is the wont of theological analysis, does not define this concept in any concise manner. Reading between the lines, however, we can discern that a common base is simply a high probability that something will be exchanged. In familiar terms, if I have six bits of gold and am starving, while you have six pizzas but are poor, we have a high probability, a common base, to indulge in a mutual exchange, an economic relationship.

In QM the cause of exchange is concisely described by mathematics. An exchange is simply the result of a *probability* of an exchange. The mathematical description of a probability involves real numbers and are not difficult to understand; a 'fifty-fifty chance' is just as real to a gambler as it is to a mathematician.

Now the consensus is that everything is caused by relationship which is the result of an exchange which is the result of a probability of exchange (a common base).

4. Inherent Tendency

Both worldviews agree (as you might expect since the column continues) on the next step; there is yet another level of causality. The probability of an exchange is the result of an abstract tendency to get involved in an exchange.

DP does not bother with detail at this point; it just says that this tendency is inherent in the nature of all things and simply calls it the Inherent Directive Nature. Atoms have one, cells have one (called the 'mind of the cell' in Unification Thought) and plants and animals have one (the physical mind).

QM calls this tendency to exchange the 'probability amplitude' and considers it the cause of probability. The mathematical description of a probability amplitude involves numbers that are so abstract they are called 'imaginary.' I went into the 'trees' of these last month (and probably lost a few readers at that point), but all we need to remember is that the scientists have a precise mathematical description of the abstract inherent directive nature.

This is the religious-scientific consensus so far: All concrete things are the result of *relationship* which is the result of an exchange which is the result of an *abstract tendency* to get involved in exchange (Inherent Directive Nature or probability amplitude, you can take your pick of nomenclature at this point).

So science and religion agree that the cause of all things is an abstract tendency to get involved in exchange. (DP, unlike physics, goes one step further and isolates the cause of this universal tendency to get involved in exchange, the enigmatic Universal Prime Energy that is an aspect of God.)

5. Form

Both QM and DP have something to say about this abstract tendency; they agree that it is not something that is formless—rather it is something with a form. Naturally the form of an abstract entity is itself rather abstract, but I hope you are getting accustomed to this by now.

DP asserts that the Inherent Directive Nature is like an idea, that the IDNs of all natural things—atoms cells, tigers—are actually ideas created in the mind of God. As such, the IDN has a form to it in the same sense that the idea for the Mona Lisa has a form in the mind of Leonardo.

So religion explains that things in the universe have a concrete form because God's ideas have an abstract form. In physics, we find a very similar concept.

The mathematical description of a probability amplitude is not a single number; it is a *field* of numbers. A field in math is similar to the agricultural kind in the sense that just as each place in a pasture has a blade of grass associated with it, each point in a mathematical field has a number associated with it. A probability amplitude is a field of imaginary-style numbers.

A field can have a form. A simple example is a contour map. Each point on the map has a number associated with it, the height above sea level (although only certain heights are actually marked in as contours). Such a map is a field of numbers and the field has an abstract form to it—the form we see concretely in the mountain range it is describing.

Science is a little more loquacious than religion in its pinpointing the cause of form: the concrete form is a result (a mathematical function) of the form of the interaction which is a function of the form of the probability (a field of real numbers) which is a function of the form of the probability amplitude (a field of imaginary numbers).

There is consensus, however: a concrete form is a function of an abstract form—be it a field of imaginary numbers or an Idea in the Mind of God, abstruse concepts both to most people.

6. Existence of the Abstract

The next consensus is that the abstract has an existence that is independent of the concrete.

Unification Thought is very clear on this point; God had the idea for all things in Nature before creation was initiated—the abstract idea is quite independent of its material expression.

To a mathematician this sounds familiar; mathematics is all about abstract things that are considered to exist quite independent of a concrete expression. The abstract entities 'one' and 'two' have a reality that is considered to be quite independent of concrete 'one thing,' 'two things.' Many millennia passed before our distant ancestors noticed the abstract 'twelve-ness' that the otherwise grossly different twelve daughters and twelve pieces of gold had in common. While it took a great leap of intuition to first grasp this, kids nowadays usually pick it up in preschool.

Although mathematics is integral to science, the existence of abstract forms is not a topic much discussed in scientific circles. We can, however, do a 'thought experiment' (the kind that Einstein did on trains moving at the speed of light) that reveals the gist of the scientific position.

The experiment is simple: travel in a well-insulated time machine back to one thousand years after the Big-Bang origin of the universe and see if hydrogen and oxygen combine to make water. If it happens (and most scientists would expect it to), then we know that the abstract form of water was in existence at that time. But for at least a million years after the Big Bang not a single molecule of water was to be found in the whole universe; the temperature was too high. Just as in math, the abstract forms of science have an existence independent of their concrete expression.

Just as the two-ness of the mathematician cannot be located in time-and-space, so the abstract forms of science cannot be pinpointed. If it they have to be somewhere, then they are everywhere—which is why water molecules have exactly the same form, whether they are in the Pacific Ocean or floating in a galaxy a billion light-years away.

7. Universal Form

The final consensus is about the overall shape and form of the abstract realm in its entirety.

There are thousands of years of Christian agreement as to the overall nature of the abstract realm: "In the beginning was the Word, and the Word was with God." This Word (or Logos or Principle) is the abstract realm that makes the universe tick. As both DP and orthodox Christianity acknowledge Jesus as the complete expression of the Word, the abstract shape of the Logos must have a lot in common with the form of a perfect human being.

This rather metaphysical concept is quite at home in quantum mechanics. If the abstract form of water has an

independent existence, then there are no reasons—except for the philosophical-bordering-on-religious ones—why the abstract forms of clay, proteins, DNA, cells, dinosaurs and oak trees are not equally independent of the concrete. As human being, in particular the human brain, is the most sophisticated form of matter we can conclude that the human form must also exist in the abstract realm.

With all this consensus, it is clear that the rapprochement of science and religion has already occurred. I'm not so sure why they remain so far apart in the world of today. Perhaps they are going through a separation period?

28. THE POSSIBILITIES OF EVOLUTION EMBRACE GOD AND SCIENCE

In this column I have been presenting an ongoing discussion of a scientific theory of evolution that is compatible with theistic beliefs. In doing so, however, I seem to have stepped on a few theistic toes. I have been told that my ideas seem to demean God's role in the creation of the physical universe. This not being so, I can only assume that I haven't expressed my ideas clearly.

The Divine Principle makes a clear statement of the relation between God and the physical universe. Because the purpose of the physical realm is to be the place where man exercises total lordship, God designed a universe over which He has no direct control. Instead, it is ruled indirectly through the natural law He created and ruled directly by human beings. God can work through people, however, which is why 'miracles' can only happen when people are around.

Incidentally, I was also asked about the role of angels in the evolution and development of the physical creation. The Principle states, however, that the spiritual and physical realms only connect through a living human being. Sorry, no angels stirring primordial soup.

The reason why my discussions seem a little dry is that science can only look at the logical structure of reality. There is no comment from science on the aspects we call beauty and love. Scientifically, what do we know about the physical universe?

We have accumulated a great deal of understanding about how the world is and how it came to be that way. We know through science the ways material can be organized on the cellular, organism and ecological levels. Through evolutionary studies we are coming to understand the ways in which these levels of organization of life have developed through time.

What science cannot answer is why does material have the possibility of developing into such highly sophisticated organized structures. All science can say is that the possibility must have existed because it happened.

It is God who created all these possibilities. It is interesting to note that our science is now developed enough to propose, through genetic engineering, to explore possibilities of life that have not yet been expressed.

When we look with the eyes of science at the sophisticated and intricate way in which life is organized we can recognize the logical genius who created them. It is with the eyes of the heart, however, that we can also recognize the artistic genius there.

A weeping willow by a pond in the mist can be breathtakingly beautiful. It is only when you become familiar with science that you begin to understand the painstaking detail that went into creating such a scene. God created the detailed possibility of such a scene. But He didn't create it directly. It came about by a long process of development.

Progressive sophistication

Science has discovered a great deal about the development of life. The origins are still obscure but one of the most interesting suggestions as to how life might have developed is that it first emerged in clay and clay structures. I wrote about this fascinating and compelling idea in an earlier column. It was God who created the possibility of clay developing simple organization which opened up the development of organic synthesis which then opened up the development of DNA synthesis which opened up the development of our sort of life with the Triplet Code method of information storage (see last column.)

Although life got going slowly, the rate of development accelerated. This is similar to the way 'low tech' methods in human society create the basis for 'high–tech' methods to develop. The geometric rise of the high–tech Western civilization on the basis of the low–tech mediaeval period is an excellent analogy. Similarly, after struggling with the low tech possibilities of clay for 1000 million years, life eventually developed the triplet code method of protein synthesis. On the 'high-tech' basis of the primate brain, however, it only took tens of millions of years for the higher tech of human beings to develop. Again, it was God who carefully designed all these possibilities. God also designed a lot of possibilities that have not yet happened.

On the basis of the triplet code, genetic control mechanisms developed allowing the emergence of muticellular organisms.

In the 100 million years or so of the Cambrian geologic period nearly all the basic forms of life and very sophisticated ecological systems were established. This is known as the 'Cambrian Explosion' and the rest of history has been variations on the themes initiated during that period. It is only with the advent of the human

race that any radically new possibilities opened up.

The diagram shows the geometric rise in the sophistication of life's organization in history. The classification of the levels of sophistication will be discussed next month. What is clear is that each level of sophistication opened up new possibilities of development. And the speed of development has speeded up.

Such opening up of possibilities has certainly occurred in human technology. One interesting illustration of this was a recent PBS show (from the BBC no doubt) on the spectacular rise in sophistication from the medieval period to Western culture when compared with the failure of the Chinese of the same period, who were at least as far advanced, to develop in a similar fashion. The conclusion was that innovation and experiment, especially in the social realm, was stifled and inhibited by the Confucian bureaucracy.

If there is one thing we can say about life, it is that it is not inhibited in any fashion.

Debate

That this historical development has happened is now considered beyond dispute in the scientific world. What is being debated is how did it happen.

A point of contention in our modern age is that since the time of Darwin, religious people have felt their faith deeply threatened by the denial of God in the random-chance-and-accident teachings of evolutionary science. I was prized out of the embrace of the Catholic faith at the age of 13 by the intellectual assurance of scientific orthodoxy.

In the 1980s we see this battle renewed in the struggle of the creationists for 'equal time' in the scientific teaching of origins. For all the political maneuverings, the creationists are doomed to fail in the scientific world because of a basic—and fatal—flaw in their argument. This flaw is that they are not proposing any scientific theory of evolution to replace the currently accepted theory.

Basically Creationists believe that God created everything in the world in a supernatural way. He then allowed His creation to run by the laws we come to understand through science. This view conflicts with almost everything science has come to understand about the history of the universe. Why it should take God (or angels) 1000 million years to make molecules of DNA when any good organic chemist can do it less than a week is a problem for the 'Invisible Hand moving Evolution' brigade.

But if you believe that God is behind the genius of nature, the random chance aspects of Darwinism are a dreadful affront, especially if your child is hearing your own beliefs belittled by scientific authority.

I believe it is possible to unite a belief in God with a scientifically rigorous theory of evolutionary mechanisms. I plan to dig into the 'hard' science again next month but, for now, I would like to conclude my discussion of God's involvement.

God's genius is visible everywhere: in sunsets, willows, eggs and french fries.

God outdid Himself, however, by creating the possibility of life becoming so sophisticated that it could become the dwelling of a spirit like His. This is us, human beings, with a brain that is the most complex and sophisticated organization of matter in the universe. We have true creativity, we can think of possibilities that never existed before, we can think thoughts that God has not thought. God got 'ice' right and 'cream' right but it took an Italian to whip up 'ice-cream.'

With the advent of human beings, new infinite possibilities have opened up. I asked a musical friend of mine a question, "In the year four trillion AD do you think that all the music there can possibly be will have been already created?" He assured me after some thought that there would still be an infinity of music left to create.

Unfortunately, through the Fall, the human race has also created possibilities of war and misery. Possibilities that have all too often been realized in a sad parody of evolutionary history. The geometric and smooth increase in sophistication halted with the arrival of man and we have yet to develop a highly sophisticated and healthy civilization. I need hardly chronicle the ills that beset our own attempts at the 'good life'.

It took 1500 million years to develop the triplet code and another 1500 million to develop muticellular organisms. On this foundation it took 500 million years to develop the primate lineage and, on this foundation, only tens of millions more to develop man. At this rate of acceleration we would have expected the human race to have developed a high level of civilization very rapidly, tens of thousands of years on a smooth curve of accelerating development.

Although the human capacities have been there all along, it is only in the last 10 – 20 thousand years that human development has got moving leading eventually to the two of the great cusps of human history—Rome and our own Western Civilization.

As we know, the cause of this is tied up in the Fall of Man, the origin of the existence of the 'evil' impulse in man. This is a topic, however, beyond the scope of a scientific discussion and we can leave it to the psychologists and theologians to tussle over. Next month, back to evolution.

29. A Cosmic Mind for a Cosmic Body

Marxism—materialism taken to its logical extreme—asserts that within the nature of energy itself is the tendency to movement. This is true enough, but it is a partial truth. The most significant—and missing—fact is

while energy does have an innate tendency to movement, that movement is always in very specific patterns.

Take a water molecule as an example. It is made of energy—the exact amount given by the E=mc2 formulae—which is structured as particles which are structured as two hydrogen atoms and one oxygen atom which combine to form a water molecule.

We do not expect to find that a water molecule is a random hodgepodge of constituents and we don't. The structure is very regular. There are certain specific angles, frequencies of vibration and stretching etc. which can be measured very precisely.

It is remarkable, if you stop to ponder it, to think that all the billions of water molecules examined by modern science to date all have the exact same structure. You can collect them from the Hudson, extract them from coconuts on Tahiti or the ancient ice-strata of the Antarctic. They are all the same.

Even more thought provoking, water molecules have been brought back from the moon and, with radio and infra-red astronomy, we can now look at water molecules millions and billions of light years away. Yet, as you probably expected, they are also all exactly the same—it is as if all the water molecules in the universe had been stamped out of the one same mold.

Most scientists do not stop and give this fact pause even though scientific thought has no explanation—not even a speculation—as to why this might be so.

Religion, however, is admirably suited to answer the question "Why?"

In the book "From Nothing to Nature" by Prof. E. H. Andrews, I found a succinct expression of a Protestant view of the laws of nature and their relationship to God.

"The Laws of science describe how things hold together in nature. The laws are the word of God's power. Moment by moment He tells the atoms, the molecules, the forces . . . what to do. They in turn, obey His voice. God does not speak actual words (it is) nearer to say that He directs them by His thoughts."

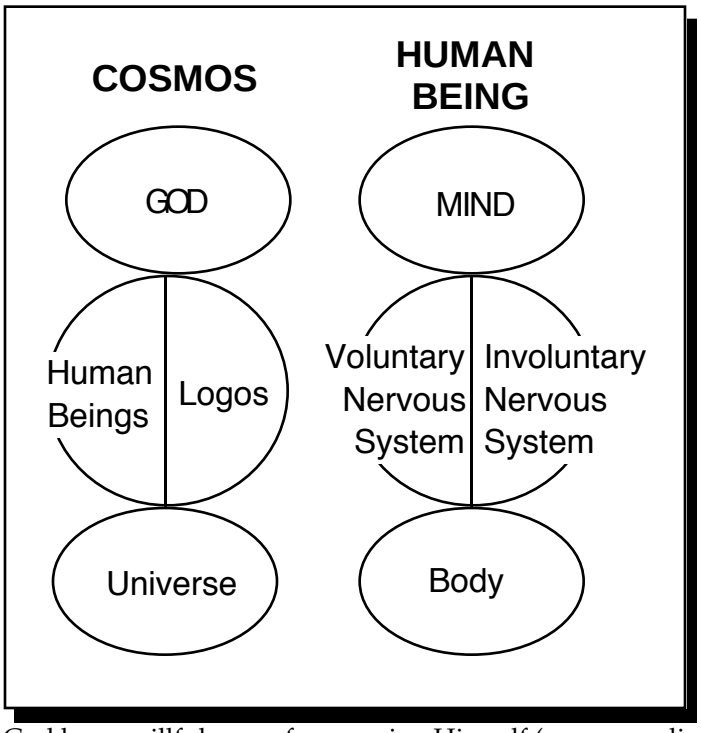
Not being able to examine the way God thinks directly, we will have to content ourselves with something a little more accessible, ourselves. For that matter, we can expect this to give us quite accurate information about God as He reportedly made us in His image anyway.

God's "nervous system"

Although a person is best thought of as an integrated whole, we can take the reductionist pathway of breaking the whole into its constituent parts.

The first great division we can make is that of mind and body. Our minds are invisible, insubstantial entities that do not seem to have a specific location in time and space. Our bodies, on the other hand, are visible, (and often all too) substantial with a definite location in time and space. The mind and the body are convenient divisions, but it is important to remember that it is merely our convenience, the mind and body are actually aspects of an integrated whole.

In a similar way, we can divide reality into the invisible, insubstantial God and the visible, substantial universe. It is similar to, though not exactly the same as, the division between the religious and the scientific ways of comprehending existence.



Our minds control our bodies through the nervous system and this control can be divided into two main sub-divisions: the unconscious—the automatic functions—and the conscious—involving our ability to will the body to do things.

In a similar fashion, we could say that God (the cosmic mind) relates to the universe (the cosmic body) in two distinct ways, the automatic and the willful. The automatic side is natural law, often called the Logos or the Word in Christianity. It is about as correct to say that God "thinks" up the sun every morning as it would be to say, "I consciously adjust the insulin level in my blood."

Every major religion also asserts, however, that God has a willful way of expressing Himself (corresponding to our conscious control of our own bodies.) This willful expression works through human beings—human beings in this view become the central nervous system of the cosmic body. This explains one of the things you might have noticed about what religions call 'miracles' or God interfering, so to speak, with the natural order of

cause and effect. Miracles only happen when human beings are around. Just as it is impossible for your mind to make your little finger move without that connecting nerve, God cannot willfully accomplish anything without a human being—His nerve fiber—to work through. This is why someone like Jesus with his deep understanding of God could assert that while you could accomplish miracles (moving mountains) with faith, without it, you couldn't.

All the major religions go a step further, they all talk about—in their different fashions—a separation between God and human beings, a Fall of Man. Squeezing this into our prosaic analogy, the cosmic mind lost touch with the cosmic body when the "central nervous system" became diseased (sin) while the rest of the cosmic body continued working through the automatic system.

Religions often emphasize the Almighty Power of God, while our personal experience is often the reverse, God often seems to be powerless to prevent injustice and the triumph of wickedness. The analogy, however, explains this, His situation is comparable to that of a paralyzed victim of a broken neck who has lost the ability to consciously will movement even though the heart still beats and the stomach still churns.

You've seen those tear-jerk movies where the paralyzed victim of a ski accident manages to twitch one finger—one nerve fiber is working! Perhaps that gives us a sense of how God feels when someone like Abraham or Moses responds, however imperfectly, to Him.

One thing is plain, from the lives of such people, and that is that all history moves when God manages to "twitch a finger."

30. THE DEBATE BETWEEN CHRISTIANITY AND DARWINISM

Some of the first graduates from the Unification Theological Seminary had the blessing of scholarships to continue their education at the doctoral level. Jonathan Wells was one of these fortunates and I recently had the pleasure of reading his doctoral thesis at Yale University, "Charles Hodge's Critique of Darwinism: The Argument to Design."

In his thesis, Jonathan creates a new perspective on the great debate that started in the last century and has yet to run its course, that between Darwinism and Christianity.

The core reason for the debate is usually considered to be about the 'Argument From Design.' Many Christian scientists had catalogued the brilliant designs found in living organisms. This argument runs: 'If living organisms are designed then God exists. Living organisms are designed therefore God exists.' According to Darwinism this apparent design is actually the random result of Natural Selection and living organisms are not designed, therefore God cannot be proved to exist by this means. Darwinism was supposedly seen as removing this "Natural Theology" (finding God in nature rather than in scripture) support to Christian beliefs and that was why many Christian thinkers attacked Darwin's theories so vehemently.

Jonathan's thesis is, however, that the Argument from Design played only a minor role in Christian theology and that something much more basic was, and is still, being debated, the 'Argument To Design.' This is, he states, 'If God exists then living organisms are designed. God exists, therefore living organisms are designed.' He finds that this is a much more fundamental to traditional Christian belief that the 'Argument From Design' which only became popular in 19th century Great Britain and America.

Jonathan uses Charles Hodge, one of the most articulate contemporary Christian critics of Darwin, to reveal the real core of the debate, that of the existence or non-existence of God. With the advent of Darwinism, the Argument to Design became: 'If God exists then living organisms are designed. According to Darwinism living organisms are not designed, therefore God does not exist.'

This is not the removal of an optional support to Christian belief, it is in logical opposition to the very core of that belief system. Jonathan makes a strong case for this as the real fount of the animosity between Christianity and Darwinism that has continued since the 19th century.

Theological insight

The theological insights of the Divine Principle shift the focus of this debate. The Principle affirms "God exists and living organisms are designed" but it takes an un-orthodox approach to stating how God actually executes His designs.

Traditional Christianity has usually insisted that God has imposed His ideas on creation by a 'miracle' (not caused by natural law) while science insists on a universe run by natural law in which there is no place for divine intervention as an explanation. Thus contemporary Christian fundamental thought as exemplified by the Creation Science movement teaches that God created each kind of organism by divine fiat but that subsequent developments occurred by the workings of natural law.

The Principle, however, does not require that God assert His power during the development of the physical universe, in fact, it strongly suggests the very opposite through the following reasoning:

God's ultimate purpose of creation is to create His children. A 'child' has each and every attribute of the parent: God is the Creator which means that His child must also be the Creator. God created the physical world in such a way that He is not the master of it, He created human beings to be the master of the physical world. (It is this absolute mastery which has allowed man to create something that is the antithesis of God's will, namely

evil.) Human beings create themselves during their period of mastery of the physical world and thus stand as equal co-creators with God and qualified to stand as God's children.

The Principle states that to fulfill this purpose, God designed the physical universe so that He can only directly effect it through human beings. He rules it indirectly through the Principle or Logos (natural laws) created before the initiation of the physical world. Miracles, the direct action of God to alter the physical world, can only occur through the agency of a human being in relationship with God as the Bible attests.

The Principle states that all of God's creative effort was done before He kicked off with the Big Bang and so the Principle can co-exist quite happily with the scientist's assertion that (when human beings are not around) everything happens because of natural law.

The Principle does say that scientists are in error when they claim that the workings of natural law can be considered 'chance and accident.' The Principle claims that the way the universe has developed, including the evolution of life, is an intended expression of the laws that have existed from the very beginning.

So, from the Principle point of view, Darwinism does not imply that living things are not designed (a double negative that means "perhaps they are, perhaps the aren't"). The Principle view removes the conflict implicit in the orthodox theology.

31. QUANTUM EVOLUTION: THE LEAP OF FAITH

If, as I discussed last month, the hierarchy that we see in nature is not such good evidence for evolution as it is generally understood—the gradual transformation of a population of one species into another—then why do so many scientists believe in evolution?

One answer to that question is found in an article in the February issue of Harpers. In his article "Agnostic Evolutionists," science writer Tom Bethell interviews Dr. Richard Lewontin, Agassiz Professor of Zoology at Harvard. He asked Professor Lewontin the same question and this was Professor Lewontin's reply:

"There is a vast weight of empirical evidence about the universe which says that unless you invoke supernatural causes, the birds could not have arisen from muck by any natural processes. Well, if the birds couldn't have arisen from muck by any natural processes then they had to arise from non-birds... Either you think that complex organisms arose by non-natural phenomena, or you think that they arose by natural phenomena. If they arose by natural phenomena then they had to evolve."

It aint necessarily so

But is that right? Are there really only two alternatives to choose from? I recall that recently the Pope visited South America and was, in a sense, asked to choose between right-wing oligarchy and left-wing totalitarianism. His answer was that there is a third alternative (As this is not a political column you'll have to read the CAUSA worldview to find out what that alternative is—not that I'm suggesting the Pope is a covert CAUSA lecturer.)

Our answer to the choice between random chance-and-accident evolution and supernatural abracadabra is the same: There is a third alternative. This alternative, for lack of a better label, I will call 'quantum evolution.' As the relationship between quantum evolution and 'classical' evolution is similar to that between quantum and classical physics, I will now detour into physics for a moment.

Quantum physics

Classical physics, as one of its basic assumptions, saw energy (the basic 'stuff' of reality) as being infinitely divisible. If you had some energy (e.g.. a Calorie that was too much for your anorexic diet) you could halve it and halve it again and again and just keep on going as far as you had the desire and patience to continue.

This assumption worked very well for 'classical' (often called Newtonian) physics such as the collision of billiard balls and other such esoterica we studied in 6th form (12th grade to you non-Brits) physics classes.

If you keep chopping at a piece of cheese long enough (and a sharp enough knife) you eventually get down to the graininess of matter that is the molecule and the atom. American cheese only seems smooth and homogeneous (ugh) because the atoms are so very, very small. In the same way, physicists in this century found that when they got down to very, very small amounts of energy it also was grainy—energy came in little packets they labeled a 'quantum' (plural 'quanta'—which Webster's informs me comes from the Latin *quantus* meaning how much.)

You can have one quantum but you cannot have half-a-quantum. To borrow from Oklahoma with a slight paraphrase, "With E it's all or nothing, it's all or nothing with E."

From this discovery came the notion of a 'quantum jump.' While quanta have very little to do with dieting (counting quanta would be most tedious as there are about a billion billion billion of them in one Calorie), to an electron in orbit about the atom they are quite substantial. A quantum of energy is enough to elevate the electron from a low-energy orbit close to the nucleus to a high-energy orbit further out. Although the electron can move back and forth from one level to the other very easily (our sense of color is a result of these jumps by the way), because you cannot have half-a-quanta, the electron cannot—and does not—exist in between these two levels. It disappears from one level and appears in the other without ever being in the space between them. There is even a phenomena (called tunneling) in which the electron can move between two pieces of material without ever being

in the space separating them.

So, a quantum jump is being in one place or another but never in between. This is why 'quantum evolution' is the perfect description for the 'third alternative' I started to discuss before I veered off into anorexic electrons.

Hop, skip and jump

Classical (or Darwinian) evolution theories allow infinitely small gradations from one species to another. In the same interview mentioned above, Dr. Lewontin—responding to the question "What about these claims: Evolution is a fact; birds evolve from non-birds; humans from non-humans?"—stated that:

"Those statements flow simply from the assertion that ... all living organisms have living organisms as parents. [and] ... there was a time on earth when there were no mammals. ... the claim that mammals arose from non-mammals is simply a conclusion."

Fine so far. There is much evidence that there is inter-relationship and organic continuity between all living things—a topic for later discussion.

However, Dr. Lewontin, as a classical evolutionist, would assert that as a lineage of parent/child parent/child was followed through time, we would find a very gradual change occurring over the eons. Another lineage in another sub-population of the same species, when followed in a similar way, might stay basically the same or very gradually change in a different way. Eventually, given enough time, the two populations would be different enough to be called different species. This gradual transformation is the key element in what I choose to call 'classical evolution.'

A quantum evolutionist on the other hand—I'm one, I don't know if there are any others yet—would see things differently. Instead of a gradual transformation of one species into another there are discreet 'jumps' between them. The transitions are not necessarily large, but the gap is very real—an organism can be on one side or the other, but there is nothing in between.

In previous columns I elaborated on the concept of an invisible pattern that guides the visible form of things—the "inherent directive nature" or what Dr. Rupert Sheldrake calls the 'morphogenetic field'. This invisible pattern is the key to understanding the 'new' evolution (which is why I spent the last two columns elaborating on it.)

So in this quantum theory, how does a new type of organism appear? During the process of reproduction the genetic material of an organism goes through a complex process—bits get broken off, switched around, sorted this way and that. Normally, the end product—e.g.. the fertilized egg—reflects the same basic pattern as the parent. It is possible, however, for the genetic material to end up in a new arrangement that is guided by and reflects a new and different pattern. Such a happening is highly improbable, but, as discussed last month, that's exactly how the invisible becomes visible.

So the progeny that grows up from the egg is different from the parent and, if successful, becomes the first in a new lineage. As we are talking about a species beginning with one, we could also call this theory 'mono-genetic' evolution. Mind you, as Marvin Gaye was wont to insist before his departure into eternity, "It takes two" so the theory will have to take this fact-of-life into account.

This points to another key difference between quantum and classical evolutionary theory. In classical theory, change occurs on the level of populations and takes a long time; while in quantum theory the change occurs on the level of the individual and happens abruptly.

As is to be expected this way of looking at evolution is already beginning to appear in scientific circles. These ideas go under the name of "punctuated equilibrium" and "hopeful monsters" and these will be the topics for next month's column.

32. The Progressive Possibilities of Evolution

In talking about evolution it is difficult not to step on a few theistic toes as some claim that such ideas demean God's role in the creation of the physical universe. If to many people God's creative role is not immediately obvious, He has no one to blame but Himself as it seems that God designed this universe to be one over which He has no direct control. Instead, it is ruled by natural law and, more recently, by human beings. (God can work through people, however, which is why 'miracles' sometimes happen when people are around.)

To artistic and spiritual type people, scientific discussions often seem a little dry. This is because science only looks at the logical structure of reality. There is no comment from science on the aspects of nature we call beauty and love. These qualities, the ones that often give people a sense of God's presence in nature, are not something that is a part of science.

What we do know through science are the ways that material can be organized on the mineral, cellular, organism and ecological levels and through evolutionary studies we are coming to understand the ways in which these levels of organization of life have developed through time. (And through genetic engineering we are exploring possibilities of life that have not yet been expressed in nature.)

Why does material have the possibility of developing into such highly sophisticated organized structures? All science can say is that the possibility for these structures must be inherent in matter because, after all, it happened.

To a theist, it is clearly God who imbued material with all these possibilities. While it is with the 'eyes' of the human heart that we can recognize the artistic genius behind nature, it is through the eyes of science—revealing the sophisticated and intricate way in which life is organized— that we can recognize a logical genius who created those possibilities. A weeping willow by a pond in the mist can be breathtakingly beautiful. It does not take any special training to appreciate the beauty there. It is only when you become familiar with science that you begin to understand the painstaking detail behind such a scene and how it came to be through the long process of development.

To an atheist, of course, the beauty and logical brilliance in such a scene just happen to be there.

Progressive sophistication

Science has discovered a great deal about the development of life. The origins of life are still obscure but the most compelling theory, to my mind, is that it first emerged in clay structures. If this is correct, then clay has the inherent potential to develop organization of information which seems to be the basic prerequisite of calling something 'alive.' Such clay structures have the potential to develop the ability to control the formation of organic compounds which opens the possibility of developing simple proteins. With the ability to make the rather sophisticated subunits of nucleic acid there is the potential to form simple types of nucleic acid which opens up the potential to develop the control of protein synthesis through the Triplet Code method of information storage which is the basis of all life as we know it today. One step builds upon a simpler step, and each step has the inherent potential to develop into more sophisticated systems.

Although life got going slowly, the rate of development accelerated. This is similar to the way 'low tech' methods in human society create the basis for 'high–tech' methods to develop. The geometric rise of the high–tech Western civilization on the basis of the low–tech mediaeval period is an excellent analogy.

After developing with the low tech possibilities of clay for 1000 million years, the triplet code method of protein synthesis eventually emerged. On this basis, genetic control mechanisms emerged allowing the development of muticellular organisms. This is much more high tech so development speeded up.

In just the next 100 million years or so of the Cambrian geologic period nearly all the basic forms of life as well as sophisticated ecological systems were established. This is known as the 'Cambrian Explosion' and the rest of history has been variations on the themes initiated during that period. It is only with the advent of the human race that any radically new possibilities opened up. On the very 'high-tech' basis of the primate brain it only took tens of millions of years for the very sophisticated capacities of human beings to develop.

Where did all these possibilities at each level come from? The question is a philosophical one, all science can do is show that the possibilities are there.

Such opening up of possibilities has certainly occurred in human technology. One interesting illustration of this was a PBS show (from the BBC no doubt) on the spectacular rise of Western culture from the medieval period compared with the failure of the Chinese of the same period, who were at least as far advanced, to develop in a similar fashion. The narrator concluded that China failed to develop because innovation and experiment, especially in the social realm, were stifled and inhibited by the Confucian bureaucracy.

If there is one thing we can say about life, it is that it is not inhibited in any fashion.

Debate

That this historical development has happened is now considered beyond dispute in the scientific world (other that details such as clay or organic soup, etc.) What is still being debated is how did it happen.

A point of contention in our modern age is, that since the time of Darwin, religious people have felt their faith deeply threatened by the denial of God in the random-chance-and-accident teachings of evolutionary science. I was prized out of the embrace of the Catholic faith at the age of 13 by the intellectual assurance of scientific orthodoxy.

In the 1980's we see this battle renewed in the struggle of the creationists for 'equal time' in the scientific teaching of origins. For all the political maneuverings, the creationists are doomed to fail in the scientific world because of a basic—and fatal—flaw in their argument. This flaw is that they are not proposing any scientific theory of evolution to replace the currently accepted theory.

Basically Creationists believe that God created everything in the world in a supernatural way. He then allowed His creation to run by the laws we come to understand through science. This view conflicts with almost everything science has come to understand about the history of the universe. Why it should take God (or angels) 1000 million years to make molecules of DNA when any good organic chemist can do it less than a week is a problem for the 'Invisible Hand moving Evolution' brigade.

But if you believe that God is behind the genius of nature, the random chance aspects of Darwinism are a dreadful affront, especially if your child is hearing your own beliefs belittled by scientific authority.

It is possible to maintain a belief in God as well as retain a scientifically rigorous theory of evolutionary mechanisms. God's genius is visible everywhere: in sunsets, willows, eggs and french fries.

God outdid Himself, however, by creating the possibility of life becoming so sophisticated that it could become the dwelling of a spirit like His. This is us, human beings, with a brain that is the most complex and sophisticated organization of matter in the universe. We have true creativity, we can think of possibilities that

never existed before, we can think thoughts that God has not thought. God got 'ice' right and 'cream' right but it took an Italian to whip up 'ice-cream.'

With the advent of human beings, new infinite possibilities have opened up. I asked a musical friend of mine a question, "In the year four trillion AD do you think that all the music there can possibly be will have been already created?" He assured me, after some thought, that there would still be an infinity of music left to create.

Unfortunately, the human race also has the potential to create war and misery, possibilities that have all too often been realized in a sad parody of evolutionary history. (Religions all agree that this is the result of some accident, the Fall of Man and the origin of the existence of the 'evil' impulse in man. This is a topic, however, beyond the scope of a scientific discussion and we can leave it to the psychologists and theologians to tussle over.)

The geometric and smooth increase in historical sophistication halted with the arrival of man and we have yet to develop a highly sophisticated and healthy civilization. I need hardly chronicle the ills that beset our own attempts at the 'good life'.

It took 1500 million years to develop the triplet code and another 1500 million to develop muticellular organisms. On this foundation it took 500 million years to develop the primate lineage and, on this foundation, only tens of millions more to develop man. At this rate of acceleration we would have expected the human race to have developed a high level of civilization very rapidly, tens of thousands of years on a smooth curve of accelerating development.

Although the human capacities have been there all along, it is only in the last 10 – 20 thousand years that human development has got moving leading eventually to the two of the great cusps of human history—Rome and our own Western Civilization.

33. Is There Hope for the Hopeful Monster?

It is nice to know that one is not alone. No, I am not getting into theology, but last month I talked about the idea of 'quantum evolution.' Although I knew of one 'quantum evolutionist'—myself—I said I didn't know if there were any others.

Well, it turns out there are quite a lot of them and the term they use is 'quantum speciation'.

In the fascinating book "The New Evolutionary Timetable" (pub: Basic Books, New York, 1981), Professor Steven Stanley, professor of Paleobiology at John Hopkins University comments:

"Quantum speciation of any sort was rejected ... in retrospect, it seems that Goldschmidt deserves posthumous accolades for his steps in the right direction." (p. 135) He later adds that "Quantum speciation entails no major elements not recognized within the Modern Synthesis of evolution. The new view simply differs in its emphasis on particular elements and in its implications for large-scale evolution." (p. 166)

What is this 'Modern Synthesis' that the quantum evolutionist Goldschmidt was excluded from?

The Modern Synthesis

Charles Darwin, author of "Origin of Species" (1859) and the founder of evolutionary thought, contributed two key elements to the basic theory of evolution accepted by most scientists at this time—what is called the Modern Synthesis. These elements are:

1. Natural Selection—the survival of a few, 'the fittest,' in a population where individuals are competing for limited resources (reflecting Malthus' thinking on human populations and Darwin's experience of animal breeding or 'artificial' selection)

2. Isolation of sub-populations of a species which diverge by continuous and gradual change over geological time until they can be called different species.

Peas in a pod

One problem Darwin's theory faced in the scientific community—not to mention the social uproar it occasioned—was almost total ignorance as to how heredity worked—why are children like their parents—and how variation appeared in a species—the raw stuff on which natural selection worked. The influence of Plato's thinking—still influential after 2,000 years—on the ideal form of a species, relegated variation to the malignant effects of the gross physical plane.

Mendel's pioneering efforts in genetics that had languished unnoticed for almost 40 years were rediscovered in the early 1900s. The subsequent discovery of the molecular basis of inheritance—chromosomes, genes and DNA—led to a temporary decline in the idea of natural selection and an emphasis on mutation as the key element in evolution. However, as most mutations are destructive, the Modern Synthesis restored the role of natural selection as a sieve through which small mutations are tested and, if beneficial, passed on. The idea of gradual change regained it's position and is now enshrined in the 'Modern Synthesis'.

A succinct statement of this current view of evolutionary theory is to be found in the popular textbook "Evolutionary Biology" written by Douglas Futuyma:

"If gene flow among local populations of a species is sufficiently restricted, the populations may so diverge that they will not or cannot interbreed; they have become different species."

One of the key elements in this theory of evolution is that "micro-evolution"—the gradual diversification of a species into races and types—is exactly the same as "macro-evolution"—the development of different species.

One important support for this theory would be the actual demonstration that different populations of the same species become unable to interbreed. This is not easily done, however, as mankind's breeding of plants and animals, in which the selective pressures are presumably much higher than 'natural selection', does not demonstrate this sort of speciation. Even after thousands of years of domestication, examples such as the dog (e.g.. the afghan and the boxer) and the cabbage families (e.g.. the cauliflower and the brussel sprout) show tremendous diversity by artificial selection, yet they interbreed and even show 'hybrid vigor' in their outbred offspring.

And I don't think that anyone would dare, in this day and age, to suggest that the black, yellow and white races were becoming different species. Imagine the struggle in the conflicting claims to be 'truly human!'

Gradualism attacked

However, this idea of gradual transformation of a species into races into different species has been challenged. In the 40s the idea that the development of species might occur at a different tempo than the development of races. This flowered in the 70s into the "punctuated equilibrium" theory of Gould and Eldredge.

This theory proposed that speciation occurred in small populations and very (geologically speaking) rapidly. This idea is hotly debated in the scientific press and receives a great deal of empirical support from the fossil record.

When you look at the bits and pieces—usually bones—that have been buried and preserved for us to dig up (does that sound too anthropomorphic, sorry) it is possible to get an idea of what was running around on the earth in ages past.

If you subscribed to the gradualistic ideas of the Modern Synthesis you might expect, looking at fossils over millions of years, to see one thing gradually transforming into another thing.

Instead, what you actually find is that one thing appears and stays pretty much the same for millions of years. Something else, similar but different enough to be given a different name, appears and also stays pretty much the same for eons. Another, not so similar as the first but more similar to the second appears and does it's thing for ages. Some of them die out but it is possible to roughly figure out who is related to who.

The actual links between all these similar but different organisms are all, without exception, missing.

Darwin recognized this from the very start. As fossil collecting was in it's infancy during his lifetime he attributed this to The Imperfection of the Geological Record. As we can scarcely claim this with our museums stuffed with old bones, another explanation is needed.

The idea of 'punctuated equilibrium' explains this absence of 'missing links' because the divergence of a race into a new species occurs rapidly in small populations, therefore you would not expect to find fossils. Only a vanishingly small number of bones survive the destructive mechanisms in nature (bacteria, weather, dogs, etc.) to make it into museums.

Hopeful Monsters

That goes part of the way; however, in the 40s some scientists went a little further.

Professor Gould, a developer of the 'punctuated evolution' theory, maintained one of the key elements in the Darwinian worldview that "evolutionary change must be dominantly continuous and descendants must be linked to ancestors by a long chain of smoothly intermediate phenotypes." ('Phenotype' means what you actually turn out like, as compared to 'genotype' which is what your genes say you are.)

A very different idea was proposed by Dr. Richard Goldschmidt, a geneticist, who argued for the sudden appearance of a species by macro-mutation. This is the long un-accoladed Goldschmidt I mentioned at the start.

His extreme saltationist (from the Latin for leap) view was that there were major changes in the genetic material that resulted in something very different to the parents being born. Such 'sports' (as they are called in animal breeding—sheep with two heads etc.) could, if they found a place in the environment to flourish (and someone else to breed with!) be the 'first ancestor' of a whole new lineage, a new species. This is why Goldschmidt coined the term "the hopeful monster".

As already mentioned, this idea was rejected by the scientific community. However, it has now reappeared.

A Dr. Robertson wrote in 1981 to the science journal Nature (the same publication that believed Dr. Sheldrake's book on the 'inherent directive nature' to be so-heretical-it-should-be-burned for those three of you who read this column regularly) that the 'hopeful monster' has:

"Been reborn as a product of the transposition of small regulatory elements of DNA, or by the translocation of large chunks of genome, leading in either case to major changes in gene expression by means of which, according to a flight of fantasy indulged by W. Doolittle, a toad might evolve into a princess with a minimum of intervening millennia."

On that and-they-lived-happily-ever-after ending I will halt to pick up on genetics and DNA again next month.

34. WAS DARWIN ONLY PARTIALLY RIGHT?

Book Review: *The Origins of Order: Self-organization and Selection in Evolution* Stuart A. Kauffman, Oxford University Press, 1993

This book deals with that perennial question with which each generation pesters the previous one: "Daddy, where did I come from?" A persistent (or bored) child can drive the answers "Mommy's tummy," "Uhh, Grandma's tummy" through to having to explain, within whatever the particular cultural milieu, the first human beings, the origin of life and the Big bang moment of creation.

Brushing aside all the elaborations and decorations that adorn such answers, they can all be grouped into two rather fuzzy sets conveniently designated the *math set* and the *magic set* of explanations.

The great divide between these two groups is the depth of explanation that is possible.

Explanations that have little or no depth to them fall into the magic camp. For the parental figure, this is by far the easiest response—the nice thing about such explanations is that the stop the kid's iteration of questions dead in its tracks.

Many religious explanations of origins have this magical element to them. While a magic wand is not explicitly mentioned in any of the scriptures I have perused, many believers seem to conceptualize the creation of the universe, the creation of life and the origin of humanity as accompanied by the sparkles of the Good Fairies at work in one of Walt Disney's creations.

This really, we might add, clearly does God an injustice. The Creator is clearly more a mathematician than a magician as witnessed by the use of the calculus in mechanics, group theory in sub-atomic particles, and complex numbers in quantum mechanics. Whatever it is that God does, it seems, mathematics is the best way of describing it: the "unreasonable effectiveness of mathematics in the natural sciences," as Eugene Wigner put it.

It is not just religion, however, that provides shallow explanations: science does it as well. While physics and chemistry are firmly in the math camp, biology and evolution often fall back on explanations involving the Goddess of Chance with biochemistry and genetics falling somewhat uncomfortably in between both camps.

A Partial Truth

The task that the author of this fascinating book has set himself is to explore the math-camp concept that the emergence of life in all of its intricacies is as inevitable as is the emergence of atoms in the cooling primal plasma, of molecules in the condensing proto-galaxies and minerals in the solidifying earth.

He has taken on quite a challenge: "…selection is viewed as the overwhelming source of order in the biological world. It follows that, in our current view, organisms are largely ad hoc solutions to design problems cobbled together by selection. It follows that most properties which are widespread in organisms are widespread by virtue of common descent from a tinkered-together ancestor, with selective maintenance of the useful tinkering. It follows that we see organisms as overwhelmingly contingent historical accidents, abetted by design" (p. 26).

"It is not," the author assures the more orthodox of his readers, "that Darwin is wrong, but that he got hold of only part of the truth." (p. xiii)

The missing element, in his view, is that natural selection works on order that emerges by other means; survival of the fittest is the secondary, not the primary, impetus driving evolution.

This places his views firmly in the math camp of explanations where understanding involves just two things: the initial conditions and the laws that apply to them. This method does, it must be admitted, have its drawbacks: the iteration of questions seems never-ending. Currently physicists have been driven back to propose initial conditions such as a homogeneous 11-or 26- dimensional hypersphere and the so-called Theory Of Everything laws that "freeze" it into the four fundamental forces as the universe inflates during the first moment of creation. Of course, there's the obvious next-question—"Where did the hypersphere come from"—and it's tempting to say "God laid it" or something equally silly from the magic camp just to get some rest.

The central concept in this book is stated in the introduction: "I believe that the origin of life was not an enormously improbable event, but law-like and governed by new principles of self-organization in complex webs of catalysis" (p. xvi). It takes Kaufmann 600 or so densely-packed pages to make his case for this math-camp concept of the origin of life as well as promoting similar ideas in the hierarchy of metabolism, genetic regulation, cell differentiation, and morphological ordering in the development of the higher organisms.

The structure of the book is highly ordered (though not spontaneously, I presume) with summaries, and summaries of summaries, that make the sometimes highly-technical discussion digestible. There are three major sections: "Adaptation on the Edge of Chaos," "The Crystallization of Life," and " Order and Ontogeny."

The Edge of Chaos

The discussion starts in earnest with a mathematically-sophisticated (the summaries are highly appreciated here) exploration of the concept of "fitness phase space" in which each of all the possible states of a system are represented by a point in this multidimensional abstraction. In this space, distance does not represent space or time but rather how well the system does in its environment.

While phase space, as it is here, is just a convenient mathematical tool in classical physics, it has become

something much more "real" in quantum physics (this also happened to the concept of a 'field' introduced by Faraday as a convenience in visualizing forces at work: nowadays 'fields' are more real than anything else to a physicist).

In the new physics the 'internal state' (which is deterministic and ruled by law) governs what goes on in the external state (which is observed as probabilistic and indeterministic). In the new physics, it is not stretching the metaphor too far to say that the phase space—going under the names of internal space and probability amplitude—being directive and abstract, plays the role somewhat like the 'mind' of a particle.

I find it significant that this author has placed such an internal space at the foundations of his biological arguments as current biology has yet to come to grips with the great changes that have occurred in foundations in physics. Although the author does not develop this approach, the hint here is that the origin of order in living systems is to be found in the internal space being explored by quantum physics and not in the external effects of natural selection as supposed by classical biologists.

In any phase space, the history of a system is a trajectory, a terrain so to speak in this abstract dimension. The author examines the terrain of fitness phase space with highly simplified models—such as the ability of peptides to bind to a specific antibody—and it turns out that the terrain can vary from smooth (ordered) to highly rugged (chaotic).

The model is then expanded to examine co-evolving sets of systems and how the landscape of one is deformed by the mutual interaction with the other. In what might be called the Goldilocks principle of evolution, it turns out that if the landscape is too smooth compared with the deformation caused by the interaction, the system is cast chaotically into states, usually ones of low fitness; if it is too rugged, the system becomes rapidly fixed into states of poor compromise and low fitness. If they are just right, however, some (but not all) of the co-evolving systems attain an ordered structure which moves through the fitness space to attain the highest possible sustained fitness.

The conclusion reached is "that complex systems constructed such that they are poised on the boundary between order and chaos are the ones best able to adapt by mutation and selection. Such poised systems appear to be best able to coordinate complex, flexible behavior and best able to respond to changes in their environment" (p. 29).

Most significantly, the derived models indicate that as the complexity of the systems under selective pressure increase, selection is less and less able to alter the properties of the systems. The author likens this to the Maxwell's demon of physics who is able to alter thermodynamic equilibrium by opening a trap door to let fast molecules through while closing it against slow molecules. A "weak" demon, however, can only shift the equilibrium slightly as the back pressure quickly becomes too much too handle. Selection, he concludes, is a rather weak demon. Complex systems, it seems, tend to remain typical members of the population from which they are derived even in the presence of continuing selection.

The implication is that if complex systems spontaneously exhibit ordering activity—those systems poised between order and chaos—rather than reflecting selection's successes, "such order, remarkably, may reflect selection's failure."

Clearly this is not straight, classical Darwinism.

Origin of Life

On this foundation, the author then tackles one of the Great Questions: the origin of life. There is a fundamental problem that must be tackled by any such theory. The basic metabolic process that underlies every living thing from an E. Coli to a blue whale is: specific amino-acid polymers make specific nucleotide polymers; specific nucleotide polymers direct the construction of specific amino-acid polymers.

While everyone is sort of in agreement that within a few million years of the earth's cooling there were amino acids around and perhaps a few nucleotides, the rest is not so clear.

The challenge is that the probability of even a minimal and inefficient self-referring protein/nucleic acid system assembling at random is of the order of one in ten-followed-by-forty-thousand-zeros. In Hoyle's famous aphorism: a lot less likely than a tornado assembling a 747 in a junk yard (even in Seattle).

As the title of this second section—The Crystallization of Life—suggests, the answer might be that "random" is not involved; just as "random" is not involved in the assembly of the a-priori highly-unlikely looking lattice of carbon atoms during the formation of a diamond.

The discussion starts with the protein- or RNA- first debate. Proponents of both have a difficult time of it. Proteins are helpless at organizing their own structures—they need some sort of template to guide there construction. So even if a highly-efficient protein were to emerge by "chance and accident" it would have no way to copy itself. Polynucleotides, on the other hand, which have no problem with replication can only be constructed as the end product of a sophisticated metabolism . While the discovery of the catalytic properties of RNA have emboldened the RNA-first cheerleaders, there is still the problem of getting even a few macromolecules around to start exploring their possibilities along with the supply of monomers they need in order to replicate.

Surprisingly, there is only a brief mention here of what is, to my mind, the suggestion that solves both problems: the clay proto-life of Grahem Cairns-Smith. In his scenario, the catalytic properties of clay (widely used

in the contemporary chemical industry) and the template possibilities of clay crystal-defects work together as a simple proto-metabolism. These structures are gradually supplanted by the products of the metabolic heights to which clay metabolism eventually attain: peptides and nucleotides developed by the clay to regulate the ionic environment and manipulate, through phosphate, the energy then available in the high concentrations of free iron. The ubiquitous presence today of metal ions in protein and nucleic acid structure perhaps being the sole remnant of this ancient golden age of clay.

The author ducks this protein or RNA problem (though he clearly favors the RNA camp) by pulling back and looking at the properties of assemblages of macromolecules in general and their emergent behaviors.

The jump in order is a "phase transition from a collection of polymers which do not reproduce themselves to a slightly more complex collection of polymers which do jointly catalyze their own reproduction. In this theory of the origin of life, it is not necessary that any molecule reproduce itself. Rather, a collection of molecules has the property that the last step in the formation of each molecule is catalyzed by some molecule in the system. …At that critical level, the ratio of reactions among the polymers to the number of polymers in the system passes a critical value, and a connected web of catalyzed reactions linking the polymers arises and spans the molecular species in the system. This web constitutes the crystallization of catalytic closure such that the system of polymers becomes collectively self-reproducing" (p. 285).

In chapter 10, the discussion shifts from molecules to modeling such self-catalytic assemblages with "random grammars:" the way strings of abstract symbols can interact with each other (with a fascinating detour into financial markets and their self-referencing habits).

Explosion of Life

The third section tackles ontogeny: the question of how a single cell can turn itself into trillions organized into a finely-tuned whole organism. As the author notes at the start, "Muticellular organisms have existed at least since the late Precambrian. There is no reason to think that the major features of ontogeny have changed in 600 million years or more."

As might be expected , the perspective here is that the emergence of this process was not a hit-or-miss accidental construct but a natural consequence of the ways in which complex assemblages of cells interact.

Rather going against expectations, if time passed is a good estimate of the probability—and statistically-speaking it is—of entering that area of the co-assembly phase space in which a new level of order is encountered, the assembly of monomers into a triplet code directed, protein & nucleic acid life structure was a lot more probable than the assembly of cells into more sophisticated structures.

While the time between the cooling of the earth (the monomers) and the emergence of blue-green algae-like life is currently estimated at less than 300 million years, it took almost 1500 million more before the prokaryote (bacteria-like) cells figured out how to cooperate as eukaryote (yeast-like) cells and another 1000 million before they, in turn, discovered how to work together in muticellular forms. Even these muticellular forms stayed pretty simple for another 500 million or so until—with the breakthrough in genetic control of ontogeny—in the relatively short period of the Cambrian explosion, all the forms of life we are now familiar with—plants, insects, and vertebrates—emerged in 5 to 10 million years according to the latest estimates.

The discussion of these areas is technical, mainly because there is a tremendous amount of work being done world-wide generating a lot of evidence that has yet to be fully digested fully. This section stands as an overview of this work-in-progress.

Again and again, however, support is found for the central tenet of the book, "that many of the highly ordered properties of genomic regulatory systems are spontaneous, self-organized features of complex control systems which required almost no selection at all. Clearly, if much of the order we see in ontogeny reflects the natural features of complex control systems, we must rethink evolutionary biology. Some of the sources of order lie outside selection" p. 408).

Cosmic test ground

The book makes a compelling case; but who is to decide if it is correct?

There is a great interest these days in the 'testability' of scientific theories. Luckily, these concepts of natural selection as the primary or the secondary force in evolution are testable as they have very different predictions about finding life on other water-bearing planets.

The prediction of selection-as-primary is that life is not likely to be found elsewhere and, if it is at all, it will be radically different. The selection-as-secondary prediction is quite different: prokaryote life should be common in the universe and should be rather similar to ours. This is good news for empire builders: the prokaryotes were responsible for creating the oxygen atmosphere, so planets that are habitable with a minimum of terraforming should be quite plentiful if this book is on the right track. (Even better for them, the eukaryotes, the muticellular organisms and the higher forms should be a lot less common so the "native" problem that caused so many problems for empire-builders in the past are unlikely.)

This is somewhat the reverse of the situation in physics today where the details of particle physics have implications for understanding cosmic evolution: the details of biological evolution will be tested by cosmic exploration. Now, while the likelihood of getting out there in the next century to test these biological theories is

small, if earth-based technology is refined to the point where it can examine extra-solar planets (none of the locals are water carrying) and if oxygen atmospheres turn out to be common, this will be strong support for the math-camp concepts of "where did I come from?"

Now all we need is someone to précis this rather overwhelming book down to a few pages that can be read to a persistent child—something along the lines of, "And in the fourth era, the minds of the molecules were poised on the edge of chaos…"

First published in The World & I, © 1993. *Reprinted with permission*

35. IT WAS CLAY AFTER ALL!

It would be an unusual person who could not, thinking back, remember playing in mud as a child and making all sorts of wondrous fancies. I was no exception, I even remember eating one or two of the nicer ones. Later, school—with its unenviable job of tidying up the bad habits of early childhood—channeled these creative talents into 'playdough' and other hygenicised clay products. But the memory of "mud, mud, glorious mud" remains.

This childish creative effort is echoed in the story of the creation of man in the Bible's, "then the Lord God formed man of dust from the ground, and breathed into his nostrils the breath of life; and man became a living being" (RSV, Genesis 2:7)

It is a beautiful image, God picks up a handful of earth and fashions it carefully and then breathes life into His creation. It might seem to those steeped in the modern scientific ideas of the evolution of man that this poetic imagery was based upon Moses' memories (the reputed author of Genesis) of his own creative efforts in the mud as a child.

Some recent advances, however, in the science of the origin of life indicate that Moses might have had a veiled scientific insight as well as being poetically pleasing.

Primordial Soup

As far as most scientists are concerned, the generally accepted idea of the origin of life goes something like this:

The atmosphere of the early earth contained gases such as methane, ammonia, carbon dioxide and water. Under the influence of intense ultra-violet light and lightning, these molecules combine to form simple organic molecules such as amino acids which are washed into the oceans. In the water these simple molecules hook up to form more complex ones. Over the eons, the ocean becomes filled with all sorts of molecules ('primordial soup' is an often used description). Simple organized forms arise by chance that are able to replicate themselves and evolution is off to a flying start.

Naturally, there is tremendous debate as to the details of this scenario, but the basic idea is that the origin of life is organic (as in organic chemistry—the chemistry of carbon compounds.)

Into this basic agreement comes an intruder—Dr. A. G. Cairns-Smith—who claims to the contrary that the origins of life were inorganic and involved clay. That's right, clay.

Two Red Herrings

In an article "The First Organisms" in Scientific American (June 1985), Dr. Cairns-Smith, Senior Lecturer in Chemistry at the University of Glasgow, takes a look at the initial promise of experiments on the 'organic origin' theory. The high-point of this theory came in the early 1950s when Stanley Miller passed sparks ("lightning") through a mixture of the kinds of gases thought to have been present in the primitive atmosphere. Water-soluble organic molecules were found that included four of the twenty amino-acids found in the proteins of all living organisms today.

Even though these experiments have not really been improved upon, and there are major difficulties with important molecules such as the formation of the nucleotides (from which the hereditary molecules DNA and RNA are formed), Cairns-Smith asks rhetorically: "Are there not still two incontrovertible facts in support" of an organic origin?

"1. The most central molecules of life are the same in all organisms on the earth today.

"2. At least some of these molecules can be made under conditions that might have existed on the primitive earth."

Dr. Cairns-Smith answers his own question—he declares these two facts Red Herrings and thoroughly misleading!

The problem is that cells are "high-tech." They are extremely complex and sophisticated with everything highly integrated and interrelated. For example, to read the instructions for making protein from DNA (the stuff that genes are made off) you need a complex set of proteins that themselves must be first made by reading the instructions from DNA which needs the complex set of proteins which needs and so on and so forth. Neither is of much value without the other and its difficult to see which could have appeared first without the other.

The "high-tech" label is very appropriate. On Fifth Avenue I can buy a very serviceable digital watch for $4

("It's from Saks Fifth Avenue—outside"). This inexpensive timepiece arrived on the Avenue via a complex route that probably started in the Far East and each component from which it is assembled is a product of sophisticated machinery which themselves are a product of other sophisticated machinery which themselves are a product and so on. A high-tech cell is just like that. Except much more so.

Evolution

Cairns-Smith's comment on this intricacy is revealing: "That kind of cleverness could only have been a product of evolution." In his book on the same topic (Genetic Takeover and the Mineral Origins of Life, Cambridge University Press) he admits to a philosophical bias:

"Behind such questions there is the assumption that life arose spontaneously on the Earth—it was not brought here by spacemen or specially contrived by God. Here I am accepting a common view among scientists of the late twentieth century."

Cairns-Smith takes a broad view of the process of evolution:

"What can evolve is .... what is passed on from generation to generation. This is not actually material but information; not substance but form. Admittedly genetic information has to be held in some material substance ... but the only long-term survivor is the information itself."

This is in accord with the concept that the form of all things is a reflection of the form of an invisible probability waveform. It is no surprise that information is crucial to the form of living organisms because information is cut from the same cloth, being also invisible and mathematical.

Where Cairns-Smith (and most other scientists) abandon information is the assertion that, "There must be occasional random changes in genetic information—mutations—and these must be inheritable .... so that there can be selection" and the emergence of new species etc.

Why the changes that are responsible for evolution are supposed to be random, unlike everything else in nature which is governed by law, is a mystery and probably the result of philosophy and/or religious beliefs (or the lack of them). We shall return to this topic but, for now, back to …

Glorious mud

As Cairns-Smith takes great pains to point out, it is unnecessary to rely on highly improbable events to explain the emergence of highly structured systems. He uses the example of a stone arch. It is possible that the stones fell out of the heavens in just such a way as to form the structure—but it is much more likely that they were built upon a much simpler scaffold which was later removed.

In the same way that a "low-tech" mechanism for killing other people—such as a bow and arrow— is made from very different material from a "high-tech" construct with the same purpose—such as a machine gun—Cairns-Smith proposes that the original low-tech living organisms were actually made of clay crystals.

"We can agree that organic molecules are the best materials for life. But the best is what you might expect evolution to arrive at; what you might expect to begin with is instead the easiest. And the easiest form of self-assembly is a spontaneous crystallization from simple, available units. Which leads us to clay."

Take my word for it (or, highly recommended, read the Scientific American paper or, if technically minded, the book) that Cairns-Smith goes into a lot of detail as to why clays make sense as the first systems with a genetic possibility.

Extrapolating wildly, he then chews on the idea of why organic material would get involved in such 'dirt' life (the original low life?). On this clay scaffold appeared molecules such as RNA—working in minor 'bit parts' at first as structural material—which "would gradually become more useful and sophisticated. Then, with the scaffolding gone, it would emerge as a necessity ... because organic structures can be built much more finely (once you have the technology), thereby achieving more intricate control."

So there you have it, clay, this distinguished scientist says, is where life began. Much later, the simple mechanisms of the minerals were replaced by the much more complex ones of proteins and DNA which later still became even more highly organized structures such as oranges, cockroaches, you and I.

So Moses wasn't so far off when he wrote about God dabbling in the mud (or playing with His soup, for that matter) when he wrote about the early days.

36. The Search for the First Ancestors

Religion and science are offspring of the same impulse to understand what it's all about, but, like ill-matched siblings with incompatible characters, they can be at peace with each other when in separate rooms but easily brawl when sharing the same place.

Religion, at least when it's in a good mood, can be warm and supportive—giving meaning and purpose to life in the grandest of terms, giving support and encouragement, friendly and emotional. One of its character flaws, however, is that in its intermittent disputes with science, it has the most difficult time owning up when it is wrong. Just look at the retreat of religion into the petulant "He made it in six days to *look* as if it took ten billion years!" Perhaps this obduracy arises because it's old and venerable and science is young and brash; perhaps it's a belief that love means never having to say you're sorry.

Science, for all its cold rationality, its rejection of purpose and meaning, it nit-picking passion for collecting facts, does not have this character flaw; it has no problem—at least when all the facts are assembled—in saying to religion, "Sorry, I was wrong."

Origins

One of the areas where they cannot avoid each other is origins: where did the universe come from? where did people come from? They have brawled over these two topics since science was kick-started back to life a few hundred years ago.

For a long time the bickering went something like this:

"The universe started suddenly with light!"—"Nonsense, it always existed!"

"The human race started suddenly with the first two people in one place!"—"Humbug, we came about as groups of humanoids all over the world gradually evolved into modern humans!"

Science has already gracefully conceded the first point: "Sorry, I was wrong, you were right! It *did* start suddenly, and light *was* the main event—I calculate the ratio as ten billion bits of light to each bit of matter."

Science is also coming around on the second point. It's not *quite* sure about it yet, but a great step in this direction appeared on page 31 of the January 1, 1987 issue of *Nature*, one of the most prestigious scientific journals in the world, under the heading "Mitochondrial DNA and Human Evolution." While the work was highly technical, its conclusions were starkly shocking:

"Mitochondrial DNAs from 147 people, drawn from five geographic regions, have been analyzed by restriction mapping. All of these mitochondrial DNAs stem from one woman who is postulated to have lived about 200,000 years ago...."

The authors, Rebecca L. Cann, Mark Stoneking and Allan C. Wilson, working at the University of California, Berkeley, had overcome a long and arduous course—not the least of their obstacles being the fulfillment of *Nature*'s very strict standards—to stake their claim to a spot in the history books.

What it took to get to that point, and the reaction and rejection they received from the "old bones" paleontologists, has been documented in Michael H. Brown's *The Search for Eve: Have Scientists Found the Mother of Us All*? (Harper & Row, NY, 1990).

While this is not the place to get into details, we can at least lay down the general outline of what they accomplished.

Mitochondria

While most have a vague idea of what DNA is (or at least have heard about it), mitochondria probably need a little introduction.

Each of the trillions of cells that make up the body are divided up into compartments that allow incompatible processes to be kept apart. The practical wisdom of industry suggests why: a manufacturing complex—which is pretty much what a cell is—would have an overwhelming problem with quality control if duplicating computer programs onto floppy disks happened in the same quarters as burning coal to power an electric generator. Keeping such incompatible processes in separate areas makes a lot of sense

One of the great advances in the evolution of living systems occurred when a cell lineage stumbled on the great advantages of compartments and went on to become the common ancestor to all higher forms of life. The other lineages remained as simple bacteria who to this day do not have inner compartments and who, metaphorically, still duplicate their computer disks right next to the furnace.

The largest of these cell compartments is the nucleus, which is packed full of DNA. Industrially, the DNA is equivalent to hundreds of thousands of computer disks (genes) loaded with the instructions needed to program the industrial robots (proteins) that run all the myriads of processes in the industrial complex. The nucleus keeps the master disks safely stored away (chromosomes) and makes duplicates of them (messenger RNA) to send out to where they are needed in the running of the cell.

The mitochondria are usually the second largest compartment in the cell (some cells have one big one, most have lots of smaller ones). The mitochondria are the industrial equivalents of central power plants that burn fuel (glucose and fat) to generate power (ATP) for distribution to the other centers, including powering the computer-department labors of the nucleus.

All higher cells (eucaryotes) have these two compartments: the nucleus for information storage, duplication and dispersal, and the mitochondria for central power generation.

An idea that was shockingly revolutionary just a decade ago—but is now almost universally accepted—is that mitochondria are descendants of bacteria (procaryotes)—that the discovery of the advantages of keeping computer disks and coal is separate compartments involved a large simple cell (which was perhaps energetically inefficient) getting invaded by a smaller bacteria (which was energetically more efficient). While this infection was probably disruptive at first (even fatal), eventually the two learned to live together in mutual harmony—the big cell doing all the work of finding the fuel, the symbiotic bacteria, the proto-mitochondria, doing all the work of burning it up.

This insight caught on quickly because mitochondria are just like bacteria; they have their own little piece of DNA (only tens of disks-worth of information compared to the hundreds of thousands in the nucleus) and they

multiply just as bacteria do: they get bigger and bigger, then split into two, with each "daughter" mitochondrion receiving its copy of the mitochondrial DNA. It is this which makes mitochondrial DNA so useful in the exploration of human lineage: its lineage is quite independent of that of the nuclear DNA.

Matrilineal Descent

The second point that makes mitochondrial DNA such a useful tool involves the way human beings are made—recall from Biology 101 that this involves the fusion of an egg cell from the mother with a sperm cell from the father.

The egg cell is huge; it has thousands of mitochondria and bulging fuel stocks all primed and ready to power the development of the new embryo. In cell terms, the egg is a big fat blimp floating lazily along, waiting for destiny to arrive.

If that destiny is not to be the flush of the menses, it will start with a single sperm piercing the egg and sparking the fabulously intricate process that ends up with a human being.

For the sperm cell, this moment of destiny does not come by waiting; the sperm has to take the gold—there is no prize for second place—in an Olympic marathon. As the run is equivalent to that from Moscow to Beijing via Mount Everest in competition with a hundred million others, the sperm can be no fat blimp; it is instead a stripped-down, sleek torpedo—just a head with its precious consignment of nuclear DNA from the father, and a powerful tail powered by massive mitochondria to push it ahead of the pack.

The single sperm that triumphs sends its head and tail to quite different destinies.

The head merges with the egg and injects the father's nuclear DNA. Inside, this combines with the mother's and is packed away into the nucleus of the cell, now a zygote, ready to provide all the information needed in the construction of a human being.

The tail of the sperm, on the other hand, exhausted from its magnificent effort, drops away, its job done, and disintegrates. The result of this sacrificial effort is that none of the father's mitochondria gets into the egg—all the mitochondria in the zygote, and the human being it eventually turns into, come from the mother.

This also makes mitochondrial DNA very useful in studying lineage: all the DNA in the mitochondria in your cells—be you male or female—came from your mother. Furthermore, your mother's mitochondrial DNA all came from her mother—your grandmother—and hers from your great-grandmother, and hers from your great-great-grandmother, etc. All the way back into deepest time.

No Sex, Thank You

Yet another inducement for scientists to shift the study of human ancestry from fossilized bones to the DNA lab is that mitochondria don't indulge in sex.

Sex is the great mixer; it takes 50% of your dad's nuclear DNA and combines it with 50% of your mother's DNA to create a whole new 100% that is you. Then, in making your sex cells, it scrambles together (recombines) the contents of the dad's chromosomes with the same chromosome from the mom. That's why kids are different from their parents and their grandparents; sex keeps mixing things up in each generation.

This is the greatest thing about sex (from the lineage's point of view, at least): you get a totally different combination each generation. This blending of characters, however, is the worst thing about sex from the study-of-lineage point of view—tracing things back in time through the lineage is impossibly complicated after only a few generations.

Mitochondria don't do sex, so the copy of mitochondrial DNA which is passed on down the generations is an exact copy every time. Well, almost exact. Very, very occasionally (once in thousands of years, perhaps) a mistake is made in duplication and the DNA is changed. Most of the time, these mistakes foul things up and are quickly eliminated from the lineage. If the error is not disruptive (a neutral mutation) and happened in the formation of an egg cell, this little change can be passed on down the lineage from mother to daughter, in the matrilinear lineage.

It is these neutral changes that enable scientists to probe deep time.

Assuming that the rate of change, estimated to be 2 to 4 percent every million years, is constant—a tendentious assumption, but one that only alters the time scale—it is possible to calibrate a "molecular clock." For example, if two lineages differ by 0.3 percent, then their last common ancestor procreated roughly 100,000 years ago.

Search for Eve ...

The Berkeley group devised a technique to isolate large quantities of mitochondrial DNA from placentas (or afterbirths, the few big chunks of human flesh that are regularly chucked away) collected from a wide variety of women representing all the races. The changes in the mitochondrial DNA were identified by snipping them into little pieces with special bacterial enzymes that are very sensitive to DNA patterns—the "restriction mapping" technique.

The assumptions they made in interpreting their results were that a particular change only happened once in history (a very reasonable assumption based on what is known) and "that the giant tree that connects all human mitochondrial DNA mutations by the fewest number of events is most likely the correct one for sorting humans

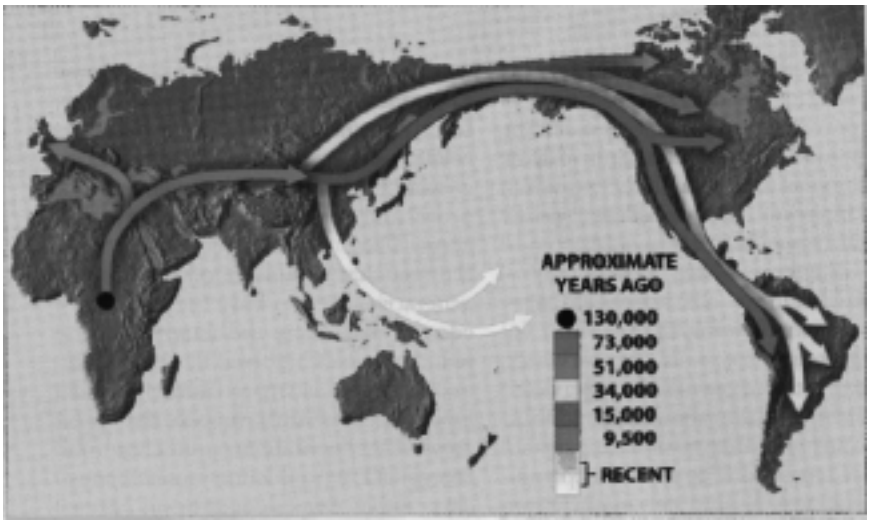
into groups related through a common female ancestry," as Dr. Cann put it in her excellent overview, "The Mitochondrial Eve," in the Natural Science section of *The World & I,* September 1987, p. 257.

From their data they constructed a lineage that could explain the global distribution of neutral mutations. Combining this with the molecular-clock estimates and with what is known about the timing of human migrations, they concluded that the best explanation of their data was that every human being can trace their lineage back to one woman who lived in Africa about 300,000-150,000 years ago, a woman quickly dubbed "the mitochondrial Eve."

As Dr. Cann is careful to point out, their data does not prove "that all humans stem from a single female ancestor," since the mitochondrial Eve is not necessarily the very first human ancestress. There is the "Smith" phenomenon to take into account, the one that plagues telephone-directory creators—one lineage can thrive at the expense of others (though, of course, this is a patrilineal phenomenon). There could have been a group of ancestral women, all of whose matrilineal lines died out except for one, the mitochondrial Eve whose DNA got passed down to every living human being living today—it only takes one all-sons generation to stop a matrilineage dead in its tracks just as an all-daughters one will end a family name.

But the research is certainly getting close to the original ancestress. Close enough, perhaps, for science to apologize to religion for deriding the Adam and Eve concept so scathingly in the past.

In the July 1997 issue of Scientific American, the work on mitochondrial DNA had progressed far enough for the presentation of a tentative map showing how human beings spread out to populate the planet as revealed by their DNA.



... and Adam

What about the men?

While there is no such thing as a mitochondrial Adam, there is another route. Sex determination—whether the zygote will develop into a boy or a girl—depends on what sex chromosome came from the father in his 50%: an X-chromosome will make a girl, a Y-chromosome a boy. Mothers always contribute an X chromosome: so girls are XX and boys are XY.

Boys get their Y from their dad, and he got his from his dad, and he got his from his dad, etc., etc., in a patrilineal lineage back in time.

Strangely enough, this sex chromosome doesn't get involved in sex. The X and Y that end up in a boy are so different that they don't scramble together the way the two X's do in girls. So, just like the matrilineal mitochondrial DNA in women, the Y-chromosome DNA in men is patrilineally passed on unchanged from generation to generation. Almost unchanged, that is, as it too can slowly collect neutral mutations which can be passed on. These are being studied and you can confidently expect this headline to appear one day: "Scientists find Y-chromosome Adam."

Surrogate Parents

It should be noticed that science's apology is conditional: while both now agree that there was an Adam and Eve, there is still a lot of debate and disagreement as to exactly how they got there—religion still has a very difficult time with the relationship to the great apes.

Religion is going to have to unbend, sooner or later, as the mitochondrial patterns found in chimps are closely related to the patterns of mutations found in humans, which implies that the zygote that developed into Eve got its mitochondria from a chimp-like ... what?

I hesitate to use the word "mother" here as it has the implication of like to like, equal to equal. As Eve is, by definition, the first human woman, this source of mitochondria cannot be human or a "mother" in the sense of equals. But, as this female-source-of-mitochondria stood in the position of a mother to Eve, the term "hominid

mother-surrogate" is appropriate.

While this does not give the definitive answer in the theological debate on, "Did Adam have a navel?" it suggests, at least, that Eve had one.

The mitochondrial linkage suggests that Eve's hominid mother-surrogate and modern-day chimps had their last common ancestor a few million years ago. Research into this is currently a hot topic of investigation.

If Eve must have had a chimp-like mother-surrogate to get her mitochondria from, you can bet that Adam must have had a father-surrogate to get his Y chromosome from.

While I have yet to see any evidence collected on this subject, bets are that the father-surrogate to Adam was also a proto-human hominid like the mother-surrogate (though, in all likelihood, they came from different lineages, since same plus same generally produces same and Adam and Eve as the first humans were, by definition, different from their parent-surrogates).

While this is speculation beyond the bounds of where experiment has reached so far, it does give hope that one day science and religion will stop their bickering about how people originated and agree that they were both partially right and both partially wrong.

37. LINGUISTIC ANCESTORS

I had no idea what linguistics—the study of languages—had to say about the origins of the human race until I came across a fascinating article in Natural History, *The First Americans*, by linguist Merritt Ruhlen (March 87.) The core of his article is a study of the ancestry and lineage of the thousand or so languages of the New World spoken by the indigenous peoples from Alaska down to the tip of South America.

The basic technique of unearthing the lineage of languages is "quite simple, involving nothing more than comparisons of basic vocabularies in a search for words that are similar in sound and meaning...such as pronouns and the names for parts of the body that linguists have found to be highly stable, often being used for thousands of years with little change in sound and meaning."

The importance of this work is that it gives a very good indication of the origins and movements of different peoples in their historical migrations over the earth.

The history of the Old World languages—and thus of the peoples who spoke them—is already well established. In Europe, for instance, there are two major families of language: the Romance languages—such as French and Italian—and the Germanic languages —such as German and English. This gives a good overview of early European history with the great expansion of the Latin-speaking peoples (Latin being the common ancestor of the Romance languages) and the migration into Europe of the Proto-Germanic speaking peoples (Proto-Germanic being the common ancestor of the Germanic languages.)

Going further back still, linguists find that there was an even earlier common ancestral language called Indo-European from which springs (among others) Latin, Proto-Germanic, Slavic (Russian, Polish), Celtic (Welsh, Irish), Greek and Sanskrit. So we can assume that, way back in history, a people speaking Indo-European spread out into Europe and Asia and, as they lost touch with each other, their languages gradually diverged.

Dr. Ruhlen's article, based on the work of linguist Joseph Greenberg, shows how the New World languages can be grouped into family trees. There seem to be three different ancestral languages which, perhaps, arrived in the Americas with three different migrations of people over the land bridge that once joined Asia and Alaska.

When all the ancient ancestral languages are compared, linguists find that they too are related to one another. This gives us a clue to the earliest periods of human history. Dr. Ruhlen concludes that, "The significant number of global cognates [words that can be shown to be related] leads some linguists to conclude that all the world's languages ultimately belong to a single language family."

This would mean that the whole human race is descended from people who lived in the same place and spoke the same language. So why is this new finding significant in the debate about the origin of the human race?

The Scientific Method

In the scientific method of discovering truth, a scientist must first come up with a theory which makes predictions about reality. The scientist then checks these predictions against the facts. If there are two theories that make different predictions, the one that predicts the way things actually are is considered true (at least until a better theory comes along).

Using this method, I would like to compare the predictions of two theories of human origins: atheistic evolution (modern Darwinism) and theistic evolution (based on the insights of the Divine Principle.)

Darwin's theory of evolution upset a lot of people because it had so much to say about the origins of the human race. Contemporary science has updated many of Darwin's ideas and has developed a theory of origins that goes something like this: By chance and accident, new qualities gradual appear in the hereditary material (DNA) which, if they are helpful, get passed on down the generations. These changes are gradual and accumulative.

Applied to the human race, this theory says that millions of years ago ape-like creatures were challenged by changing environmental situations. Certain useful qualities appeared at different times (such as a bigger brain,

less hair, upright stature, complex vocal ability, etc.) which helped those individuals who inherited them to prosper under the challenge while those who did not inherit them, gradually 'fell by the wayside.' As these animals became more and more human-like, they spread out and multiplied.

As the ability to speak gradually developed we would expect language itself to gradually evolve in many different areas. These languages would have nothing to do with each other.

So there we have a prediction by the theory of atheistic evolution: many different and distinct languages. This prediction is not upheld by the linguist discoveries we have already discussed.

Theistic Evolution

The theistic theory of the evolution of life predicts what is actually found, one ancestral language.

In the theistic view of the development of life, every new species arises as the offspring of one couple. These two individuals are created separately by the intelligent rearrangement of the genetic material in the initial cell from which they developed (the zygote.) This new arrangement of the DNA expresses one of God's new ideas. There is nothing gradual about this theory, the new species appears with all of its functions present from the very beginning.

Applying this generalized view to the human race, we see that the first people would have had all the human qualities present from the start, including the ability to speak. We would also expect that many generations would pass before there were people in great numbers. As it surely didn't take long before a simple language developed, we would expect there to be one language before migrations would separate different populations enough for different languages to develop.

There you have it, two theories of origins—modern "chance and accident" Darwinian theory and the new theistic theory of evolution—with two different predictions, only one of which is supported by modern linguistics.

Science and Religion

There is a great debate in America right now about the teaching of evolution alongside the ideas of 'scientific creationism.' The great cry is that creationism is religion and should not be taught as science. I do not intend to go into that matter, but as the Divine Principle viewpoint is very different to creationism, I would like to summarize (my understanding) of the origin and history of man as viewed through the insights of the Divine Principle.

The human race started with the first couple millions of years ago. (Much evidence is accumulating that places our origins in Africa.) Because of the Fall of Man, they and their descendants were mentally and spiritually brutish.

During the succeeding millennia, God and man had no communication—each generation was the same as the preceding one and there were no insights gained that could elevate man's situation. (The '10 generations' mentioned in the Bible into which this long period of time is condensed represent the rare times that God was able to impart some small insight to an open person.)

Archaeological research has shown that during this long period of time, the human race spread out into Africa, Europe and Asia. During the Ice Ages (the last one only ended 10,000 years ago) the amount of water locked up in the ice sheets was so great that the sea level was lowered and a land bridge opened from Siberia to Alaska. People migrated over this bridge (probably more than once) and spread out all the way down to the tip of South America. Another land bridge probably allowed people to spread down to Australia.

As they went further afield, the languages they used diverged into the thousands of languages we see on the earth today. The Tower of Babel in the Bible probably reflects the ancient memory of a time when there was only one language (which I think would have stayed the universal tongue if history had developed rapidly without the Fall of Man occurring.)

God's History

Finally, I would like to insist that the viewpoint I am discussing is science—the theory and its predictions are open to testing— and not a view forced on us by belief in the Bible. This is because the Bible is a record of what God has been up to in history and most of human history has had very little to do with God.

The Bible only records those special periods of history when God was trying to accomplish something major. (If you want the details, read the Principle, it's very interesting!). In outline, God has a purpose He is working to fulfill through history. The basic tactic of His plan is, that at certain periods in history, many people become receptive to insight about the material world and, at the same time, one person receives a whammy of a spiritual insight. The plan is for the two areas of development to unite together moving historical development closer to the ultimate goal: The Kingdom of Heaven on Earth and in the Spiritual World. (As to what this is and why it has taken so long, you'll have to read the book.)

The Bible informs us that there were not many times in history when this plan of God had a chance to advance.

In the age of Noah, after many, many millennia of nothing much happening, there was the development of organized agriculture, cities and simple political systems.

Later, during the age of Abraham leading up to Moses (entering the period where we have a written record) the great civilizations of Mesopotamia, Egypt, the Indus Valley and China arose.

Heralding the coming of Christ, the Axial Period saw a world-wide development including the rise of Greece and Rome in the West, and the development of the Buddhist and Confucianist cultures in the East.

We ourselves are fortunate to be living in a such a period of history when everything is again developing at a breakneck speed. We live at a time when people have food and material comfort available to such a degree that some of the people can take the time to specialize as linguists and become smart enough to speculate about our first ancestors and the first language.

And I think those linguists who think we come from one family are on the right track, don't you?

38. HIERARCHY OF LIFE

If you had ever studied science in school as did myself—spending many an hour learning the peculiarities of Chemistry with rugby-loving wimp-ignoring Welsh-adoring Mr. Thomas, dissecting out the intricacies of Biology with pepper-tempered dapper Mr. Ridgeway or formulating the motions of Physics under the glinting gaze of the rarefied Mr. Reese—one could be quite forgiven for assuming that the laws of the various departments of science were as diverse and independent as the men who taught us.

If pushed, however, most scientists would agree that the particular laws of each discipline are just a part of a unified, overarching single Natural Law, corresponding to the single waveform we discussed in the previous chapter. What can we deduce about this overarching natural law, this unified waveform?

First we know that the form of something is the reflection of the form of the invisible wave function associated with it. Second, there is a hierarchy in the natural world as everything is made up of smaller things assembled together. Each of these smaller parts, however, will have its own associated waveform. This implies that there must exist a hierarchy in the invisible forms of the wave functions.

For instance, while the water molecule has a certain characteristic form which includes the forms of hydrogen and oxygen, there is more to the form of water than just the forms of hydrogen and oxygen.

The invisible probability field exists in the simplest to the most complex entities and they form a hierarchy: the pattern of hydrogen is a part of the pattern for water which is part of the pattern for a cell which is part of the pattern for the kidney etc.

So the form of the overall unified waveform can't be the form of the sub-atomic particle because atoms are more complex, it can't be the atom because molecules are more complex. All we can really say about the overall wave form is that it must be at least as complex as the most complex material object. It could be more but it can't be less.

If you don't know what the most complex material object is take a look in the mirror. You are it and so am I. The form of that wave is (at least) that of the human being. This can be equated with the Logos of religion which is considered to be the cause of the form of all material objects.

A Debate

This hierarchy is the cause of a debate that is occurring in the halls of evolutionary science. This debate was neatly summed up in an article by Tom Bethell in the February '85 issue of Harpers Magazine.

In this article "The Taxonomic Case Against Darwin," he describes the intense challenge posed to orthodox Darwinism by a group of scientists (labeled 'agnostic evolutionists' by the author) who extol the virtues of 'transformed cladistics', a new theory of taxonomy.

Now the Purpose in Life to a taxonomist is to classify and categorize the myriads of living and dead organisms, echoing the ancient task accomplished when, "... every beast of the field and every bird of the air, and [God] brought them to the man to see what he would call them ..." Genesis 2:19. A clear claim for taxonomy to be the oldest profession.

The cladists claim that all we can be sure about are the positive and verifiable characteristics of the various species by which we can classify them and see how they all fit together into the patterns that exist in nature. They claim that it is not possible to show ancestral, evolutionary links between species.

Bethell interviewed a Dr. Nelson on the staff of the Natural History Museum in New York. He asked him about fossils: "Don't we know that evolutionary theory is true from the fossils? Like most people, I thought the natural history museums had pretty much worked out the fossil sequences, much as in an automobile museum you can find the 'ancestors' of contemporary cars lined up in sequence."

Dr. Nelson replied: "Usually with fossils all you find are a few nuts and bolts, an odd piston ring, maybe, or different pieces of a carburetor ..." He claims that too much importance had been attached to fossils.

As Bethell puts it, "To the cladists, the science of evolution is in a large part a matter of faith—faith different, but not all that different, from that of the creationists."

So what solid evidence is there for evolution? Dr. Platnick, a cladist also with the Natural History Museum, told Bethell that: "The evidence was to be found in the existing hierarchical structure of nature. All organisms can, as it were, be placed within an inter-nested set of 'boxes.' The box labeled 'gazelles' fits in the larger box

labeled 'ungulates' (animals with hoofs), which fits inside the 'mammals' box, which fits ... inside the 'vertebrates' box."

Cladistics is simply recognizing the hierarchical nature of the patterns and forms taken up by living things.

Chaos

It is important to realize, at this point, that the waveforms of science are not like the blueprints we use to give form to a house. The blueprint specifies exactly where every little bit goes. The waveform is not so specific. In the discussion of the form of an atom, it should have been clear that, while the equations describing it are clear and precise, the form itself is fuzzy—sometimes the electron is here, sometimes there, very often near here, hardly ever over there.

In the age of computer, where we put exact information in and expect to get exact information out, it is odd to think of precise mathematical equations (by which we describe these functions) giving fuzzy results. Odd, but common. In fact most of the equations of science have this fuzzy nature—in mathematical terms, they are non-linear—and only the few odd exceptions behave in a simple fashion, they are 'linear.'

Non-linearity in science is called chaos, and the study of it has become a multi-disciplinary effort. James Gleick had a surprise best-seller with his, "Chaos: Making a New Science." Common sense might suggest that simple equations govern simple systems and that complex equations govern complex systems. The study of chaos, however, has disproved this, for, as Gleick says, "physicists, mathematicians, biologists, and astronomers have created an alternative set of ideas. Simple systems give rise to complex behavior. Complex systems give rise to simple behavior. And most important, the laws of complexity hold universally, caring not at all for the details of a system's constituents." He also quotes a scientist who said that to talk of non-linear systems in science is like talking about non-elephant animals in zoology.

The fascinating thing, is that chaos has a form to it. The universal equations of chaos reveal their forms through the graphics capability of modern computers. Although the equations of chaos are discrete, they are not like geographic coordinates—find object X at location Y—they describe "orbits in phase space," which, like the equations of quantum theory, do not give precise details but only the overall state of the system.

Natural laws are usually of this nature, they govern but do not control, they determine the overall shape but not the precise events taking place.

39. Evolution and Information in the Age of the Computer

Many people have the sense that God is excluded from modern science, especially so by Darwin's theory of evolution. Darwinism supposedly explains how life in all its complexity came about without God, thus undercutting religious belief. You can side with science or religion, so the concept runs, but you can't have both.

This widely believed concept is, however, false. I find, upon examination, that a remarkable amount of modern evolutionary thought is intellectually very compatible with a belief in God.

Darwin's theory of evolution, of course, has gone through many changes since it burst on the intellectual scene not so very long ago. And there is still plenty of debate about the details. (If you want to keep up with the 'evolution of evolutionary theory,' Harvard professor Steven Jay Gould writes a column "This View of Life" in the "Natural History" magazine each month which provides a very readable account of these developments for the layman.)

Although the details are under debate, the basic precepts of evolution are not. Three of these basic precepts at the core of Darwinism are:

1) There is a continuity of 'lineage' from the most simple forms of life (such as bacteria) to the most complex form of life (which is us);

2) Complex life forms develop out of less complex ones over periods of time; and

3) The process of evolution is the cumulative result of random chance and accident.

Which of these basic elements of modern Darwinism are incompatible with a belief in God? Lets take a look at each in turn.

Continuity of lineage

How about the first point, the continuity in the lineage of all life? It had better not be this one as this aspect of evolutionary theory is as firmly based as anything else in science.

It has become very apparent to modern science that all life forms are related to every other life form. You might bemusedly think, "What have I in common with a fire-fly?" A lot more than you might be aware of.

Did you ever see a biochemical flow-chart of what goes on in a cell? We used to have one covering the 20 foot wall of the lab where I worked in England. The writing was so tiny, you had to get very close to read it. The astonishing thing was that the mass of detail on the chart only dealt with the biochemistry that all living things have in common. It didn't touch on the differences, the things that make you and a fire-fly so unlike each other. You burn sugar for energy by exactly the same (highly complex) method as the fly does, as do all living things.

Then there is DNA. Just like a computer uses a disk drive to store information until needed, a cell uses DNA.

And they both work in a similar manner.

A computer lays down a long rows of magnetic 1 and magnetic 0, two different information-bits that can store all the information the computer needs to do the most complex tasks. The computer uses the 1's and 0's in groups of eight (called a byte), and it is in the precise order of the information-bits that information is stored. For instance, the letter 'A' is coded as 01000001 while an 'a' is coded as 01100001.

My Mac computer on which this article was written stored all of this brilliant column in just 75,000 of those information-bits while my ten-megabyte disk can store 80 million of these information-bits. Everything the computer needs to know is stored in this simple manner.

But believe me, (or ask any computer owner) if you get just one of the information-bits in the wrong place you end up with garbage or, if the error is in a particularly sensitive spot, the dreaded system-crash. The order has to be precisely right. This pickyness is the source of, as one advert had it, of the four most dreaded words in modern business: "The computer is down."

In a similar way the cell keeps its information in long rows of four molecules called A, T, C and G, the information-bits that make up DNA. A human cell has about three billion of these information-bits in the DNA neatly coiled up in the chromosomes. About ten feet of it in each tiny cell! Just like the computer 'byte', the cell uses these information-bits in groups of three. For instance, the amino-acid glycine is coded by GGU while alanine is coded by GCG.

Each of your trillion odd cells gets an exact copy of the DNA and each type of cell knows just where to read off the information it needs to accomplish the tasks it must perform. A liver cell probably never uses the information needed by other cells to make blue eyes, but it's all there in its DNA if it ever does need it.

But this lengthy sequence of information-bits has to be precisely correct. If you understand how just one information-bit wrong in a computer can cause problems, you can believe that getting one of the DNA information-bits wrong can also cause havoc. With a lot more serious consequences. Two instances: Sickle-cell Anemia, a debilitating disease which afflicts millions and kills thousands each year, is known to be caused by having just one information-bit wrong out of all those billions in the DNA; and one of the many causes of cancer is thought to be this type of 'data-error' creeping into the DNA of vulnerable cells. Luckily enough, the DNA duplicating mechanism in cells is so well (dare I say) designed, that these types of errors hardly ever occur.

What has all this technical stuff got to do with the continuity of all life? Back to computers for a moment. If you have ever used one you have probably stumbled across the real inconvenience of 'incompatibility.' I use a Macintosh computer, my friend uses an IBM. Do you think my Mac can read the valuable information my friend has stored on his IBM disk? Not a chance. They use totally different ways of laying out the 1's and 0's on the magnetic disk so they are 'incompatible.' The computer designers each started from scratch and came up with very different methods of doing things.

The remarkable fact about all living things, however, is that they are all 'compatible.' Every single living thing uses exactly the same system of storing and retrieving information from the information-bits of DNA. This system is called the 'genetic code' and it is used by all life.

For example, if you took the DNA from a cell of a fire-fly and put it in one of your cells, your cells could glow in the dark. (Such experiments have actually been done with plants.) Your cell would have no problem reading the information in the fly DNA on how to make the chemicals that make that lovely glow. This is just as true for all bacteria, plants and animals. This is the basis for genetic engineering. You might not be very pleased to know that when your DNA is compared to chimp DNA, scientists find only a 3% difference! They are almost the same. Don't worry though, that small difference translates into about ten million information-bits, plenty of room to store the information the cell needs to make you look quite un-chimp like! Vive la difference!!

For these and many other reasons, this first aspect of evolutionary theory, the continuity of all life, is firmly entrenched in scientific thought and I doubt if it will ever be dislodged.

Such an understanding, however, is only a problem for believers if they insist on 'creation out of nothing'. If the first fire-fly appeared out of nothing and the first human did as well, there really is no reason for them to be at all similar (a la IBM and the Macintosh).

Change through time

What about the second aspect of evolutionary theory, cumulative change over time? This also is really not a problem for believers. Both the Bible and the Principle explanation of Genesis agree: God created everything in stages. If there was no reason for a logical progression of creation through time, why couldn't the Bible read:

"...and there was man. On the second day God created the animals. On the third day He made the plants for them to eat. On the forth day He made the earth for them to live on ...."

The Divine Principle explains that God does not create out of nothing: He creates new things by reorganizing what is already created.

First of all, energy was created (and where that comes from involves dimensions of reality that are much too spiritual for current science to deal with). Organizing this energy in various patterns produces the subatomic particles which are eventually organized into the material universe, including the earth, we are familiar with. Non-living material was then organized into more and more complex patterns until we say those structures had 'life'. These simple life forms become the working material to create more and more complex living forms.

Eventually, there was you.

The fossil record is very clear on this point, simple comes first, complex later. Some people, taking the Bible in a literal sense I believe was never intended, ascribe the world-wide layering of fossils to the Flood. That there was a great flood is open to debate, but to ascribe the fossil record to it will never win over the scientific community.

However, unless you insist that God creates things out of nothing each time—perhaps like a Disney elf with a shower of sparkles: pouf, a frog—this second aspect of modern Darwinism is really not a problem for the believer.

Probability

As you have probably guessed if you made it this far, it is the third aspect of contemporary evolutionary theory that is incompatible with belief in God.

Actually, the third point about random-chance-and-accident is a very difficult point for scientists as well. And the problem has to do with 'probability.'

In the book "Darwin Was Wrong - A Study in Probabilities" (New Research Publications, New York 1985), I. L. Cohen goes to the trouble of calculating some of the various probabilities involved in random-chance-and-accident evolution.

Just one of his examples—and if you are interested in a lot more I recommend reading the book—is one aspect of the explosion of life that occurred at the beginning of the Cambrian geologic era of the earth—about 570 million years ago. Before that time, there were only simple bacteria-like forms on the earth. Suddenly there are lots of complex little crab-like creatures around with intricate eyes, hearts, shells etc. (One of the major debates within Darwinism is just how fast such changes occur, but in the fossil record it's fast!)

These later life forms are a lot more complex that the earlier ones so a lot more information has to be encoded in the DNA. The little crab-like creatures need about 490 million information-bits more than the simple life forms. What is the probability of all this additional, precise information appearing by chance and accident?

Author Cohen never actually calculates the probability of this happening by random-chance-and-accident because the figures get much too cumbersome and huge even for the best computers. One calculation he does perform on a difference of just one million information-bits puts the probability of the change occurring by random-chance-and-accident at only one in a number so huge it would take about twelve books just to print it, a one followed by five million zeros.

Highly unlikely to happen? You can bet on it.

Those odds are about the same as my chance of winning the New York lottery 715,000 times in a row without losing once. Compared to that number, the probability of my winning $16 million in this week's lottery—a one in ten million chance (a one followed by only seven zeros)—is absolute certainty. I've got my ticket, but I wouldn't write those begging letters to me asking for some of the money for your pet project just yet.

Even more unreasonably, such a fantastically improbable event is not supposed to have happened just once in the development in life's complexity. Such unlikely happenings are supposed to have happened millions upon millions of times in life's long history. That's why scientists have a problem with this random-chance-and-accident aspect of evolutionary theory: you just can't beat the odds.

Not convinced

They don't convince me! Now if they want to believe in random-chance-and-accident that's fine. After all, there is religious freedom in this country. But intellectually, the idea demands a leap of faith greater than anything Jesus ever asked for.

Chance and accident really doesn't make sense as the source of all of life's brilliant and beautiful complexity. The only thing that does make sense is that intelligence is actively involved. But, as this is the last few lines of the column, I will leave that subject for another day.

God clearly has a place in modern evolutionary theory, you can't keep Him out. In fact, you cannot make sense of evolution without involving God.

Now isn't that nice to know.

40. The Hard Part of Life is the Soft Part of Computers

One of the greatest miracles in this universe is life, and it is through science that it is possible to glimpse the Genius of the Mind that caused it. Living systems, unfortunately, are so complex that science often smothers understanding with detail. One of the ways of avoiding this is to use analogy. Our choice of analogy, however, is limited by the culture we are immersed in.

A couple of hundred years ago, for instance, the most intricate systems that were well understood were clocks. The height of technology. So in those days analogies about how the universe worked often involved clocks.

Just few decades ago, the example of high tech was the telephone system. Being a bit of a bookworm growing up, I used to enjoy browsing through the 10-volume “Arthur Mee’s Children’s Encyclopedia” my father had

purchased in the fifties. I can vividly recall one of the illustrations that purported to explain how the body functioned by an industrial analogy. The stomach had men with shovels moving food through sluices, the lungs were giant bellows etc. And there, coordinating it all in the brain, was a cute little telephone operator plugging away at her telephone board.

This is all now passe: the height of innovation these days is the computer. So, rather than fight against our cultural milieu we can use a computer analogy to get a grip on the complexity of living systems.

Soft & Hard

The key to understanding a computer system is to realize that it is composed of two separate, but highly integrated, systems at work together. These two systems involve two types of interactions. One is made up of physical interactions: flows of electrons, motors turning etc. This is called the 'hardware' of the computer. The other system is made up of what we might call abstract interactions involving patterns that store and transmit information. This is the 'software' side.

It is the software, the abstract information, that is the 'real' computer but the interesting thing about software is that you can't have software without some kind of hardware. An abstract pattern has to be a pattern *in* something. (The converse, unfortunately, does not hold. A computer after it 'bombs' is an excellent example of hardware without software.)

This article is being written on a friendly (sorry to bring religion in so soon) Macintosh computer and each incisive thought is being stored as words on a magnetic disk. The working of the computer involves manipulating such information, and as mentioned, this abstract 'soft' information is always associated with a concrete 'hard' expression. On the floppy disk the information is a pattern of magnetic poles, in the computer itself it is a pattern of high and low voltages, on the screen it is a pattern of light and dark, out of the laser printer it is a pattern of black toner on white paper.

Exactly the same sort of distinction can help us understand living systems.

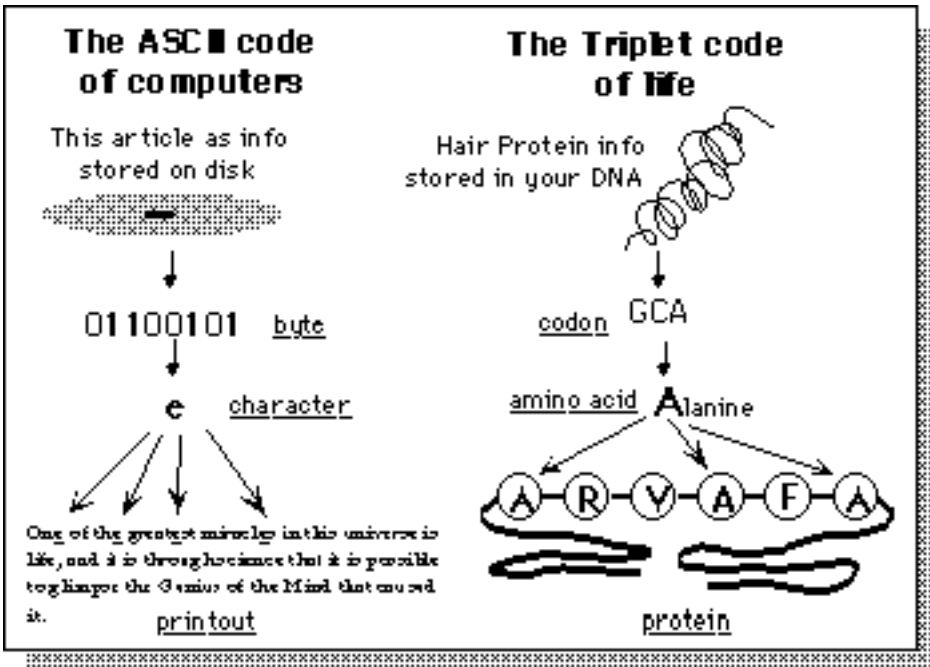
Living systems can be divided into two separate but intertwined systems, one involving physical interactions and the other involving abstract interactions.

The physical system involves the ebb and flow of electrons, atoms, molecules, cells etc., the physical interactions that bind the material stuff of life together into the hardware side of life. The abstract side involves the ebb and flow of abstract patterns (with a hardware expression, naturally) that store and transmit information in the genetic system, the software side of life.

Seeing as humans designed and built them, it is not surprising that the workings of both the hard and soft sides of computers are well understood. This is certainly does not hold for living systems, but then we are not its creators. Some things, however, are already well understood such as the storage of information in DNA, the genetic material of the cell. It turns out that DNA and computers have a lot in common when it comes to data storage.

Two Codes

Both living systems and computers use analogous ways of storing basic information: living systems use the 'triplet code' and computers use the ASCII (ask ee) code. Each is a standardized way of storing information and the differences between these two codes are actually quite superficial:



The unit of ASCII code is called a 'byte,' a pattern of eight bits'. There are only two of these, the 1 and 0. Examples of ASCII bytes would be 11101111 and 10101010. The unit of the triplet code is a 'codon,' a pattern of three chemical 'bases.' There are four of these symbolized by A, T, C, and G. Examples of triplet code codons would be AAA and CAT. (Computers also use another pattern of bits, the binary code, as it is much more convenient than ASCII for doing arithmetic but, as cells do little adding and subtracting and quite a different sort of multiplication and division, we can ignore it for our analogy.)

It is the translation of these codes—what they 'mean'—by the hardware side that is fundamental to the workings of life and computers.

Much of the work of computers involves the manipulation of letters, numbers and punctuation, and each of them has an ASCII code assigned. For instance, the byte 01100101 is translated as 'e' (not 'E' which has its own byte assigned.) To an IBM or an Apple the world over, this particular byte will be an e at the hardware end, appearing on the screen or on the printer paper. Amazing as it seems, all my computer is doing as I type this article is manipulating patterns of ones and zeros, the ASCII codes. Simple but brilliant.

Life does something similar.

All of the work of the genetic system is the making of protein as everything that happens on the hardware side is the result of the activity of tens of thousands of different proteins. It is the proteins that actually make things happen—blue eyes, black skin, everything. If the genetic system makes the right proteins, the proteins will take care of all the rest.

A protein is made of long strings of amino acids—think of them as Bush pearls on a string. There are 20 different amino acids and the function and activity of the protein—be it the keratin protein of hair or a deadly neurotoxin—is determined by which of the twenty is at each position in the chain. So the task of the genetic system is to make sure that the correct amino acid ends up at each position. Just how it does this has been revealed only during the last few decades of research.

Production lines and Storage Bins

Each of the 20 amino acids was assigned a triplet codon billions of years ago during evolution and they have remained fixed ever since. For instance, the codon GCA is translated as the amino acid *alanine*. To a mouse, a man, a blueberry or a bacteria, GCA means alanine, the triplet code is truly universal, evidence of the unity of life.

It is such triplet codons that connects the abstract information in the genetic system with the hardware ('wetware' would be a perhaps more appropriate) protein using a bunch of molecules that are containers just right for holding one amino acid each (they are called *transfer RNA* if you like to know hardware details). Each of these containers (which are close cousins to the famous DNA molecule) has a triplet code tag identifying which of the amino acids is inside.

It is these tagged and boxed amino acids that allow the protein-making factory inside a cell to translate the instructions from the chromosomes into long strings of amino acids.. These factories (the ribosomes) are like production lines endlessly adding amino acids to growing chains. When the instructions from the genetic system say "add an alanine" all the line has to do is fetch the container with the right tag (just like a biological storage bin but we're not using the 'automated factory' analogy this time).

The way of translating the instructions from the chromosomes using these labeled containers is ingenious and involves the complement of the code, a method also used in computers. For example, there are many good reasons (though I can't quite put my finger on one right now) why computers do subtraction and division using the complement of the binary code for the number rather than the actual code itself. The complement is very simple, change all the ones into zeros and all the zeros into ones.

The complement of the triplet code is a little more complex. A and T are a pair and C and G are a pair, so to make the complement of a codon (called the anticodon) replace the A's with T's and the T's with A's. Do the same

for the C & G couple. The anticodon for alanine is the complement of GCA, and it is this anticodon CGT that is used as the tag on the amino acid container for alanine.

The instructions from the chromosome come as strings of codons. To translate this string of codons into a string of amino acids, the production line just matches the anticodon tag on the amino acid container with the codon on the instruction. The correct amino acid has been selected and production of protein continues.

This is basically how the software is translated into hardware, in computer lingo the 'interface' between the genetic system and the rest of the cell. Just as the computer works by manipulating patterns of ones and zeros, all of life's activity, form and function is the result of the manipulation of the patterns in the triplet code. Simple, but exquisitely brilliant.

How do the instructions arrive at the production lines from the chromosomes? They can be thought of as signals and instructions emanating from the bottom of an information hierarchy. "Although the nature of the molecules responsible for the signaling is still largely unknown, the techniques of molecular biology are beginning to reveal how genes direct the process. … The picture that emerges is of a control hierarchy, with genes at each level passing instructions down the chain." (Tim Beardsley, "Developmental Dialectics," Scientific American, Nov. 88, p. 40.)

It is customary in science to illustrate the relationship between two different things by plotting them on the two axis of a graph. So we could graph the flow of abstract information (the software) on the vertical axis, and the ebb and flow of the substantial hardware on the horizontal axis. We would then say that all living systems, like computers, involve the integration of a vertical, abstract aspect with a horizontal, physical aspect.

Programs for Life

Both computers and living systems work in a hierarchical fashion, a pyramid with simple information or instructions at the bottom and the complex ones at the top. The lowest level involves basic codes such as the ASCII and triplet code. These codes can be combined to make the next higher level in the hierarchy.

In the computer, the level above the simple code is the program level. A program is a sequence of characters stored in the computer as ASCII codes which makes the hardware side of the computer perform. For example, this little program in the BASIC language will make my computer print

Please type in your name

on the screen, wait for me to type in my name, and then store what I type in the computer memory:

INPUT "Please type in your name"; NAME$

In a cell, the level above amino acid codes deals with proteins. The storage of protein information on DNA is very simple. A simple example is the main constituent of egg white, a protein that is a chain of 630 amino-acids making up a passive, if rather tasty, sort of protein. Chicken DNA stores the information needed to make this as a sequence of 630 amino acid codes on the DNA. This sequence of codes is called the 'gene' for egg protein. (So if someone tells you, "It's in his genes," they are talking about his proteins.)

Both the program and the gene make the hardware side perform; and a computer program is a sequence of ASCII codes while a gene is a sequence of amino acid codes; two good reasons why a gene can be considered a 'protein program.

Both computers and cells are very unforgiving at this level. Just as a single mistake in one character of a program (e.g. UNPUT) will cause my computer to err, a glitch in a protein program can cause all sorts of damage. The debilitating disease sickle cell anemia, for instance, is caused by a single base change that results in just one of the 600 amino-acids in the hemoglobin protein being wrong. Every aspect of the disease is traced to this one change.

Keep the Master Safe

The protein factories don't use the chromosome genes directly for reasons well known to the computer world. Almost every computer program I have ever purchased came with a stark warning on the floppy: "Never Use This Original Disk; Always Work With A Copy." This is good advice, if you ruin your 'master' disk while using it, you have to go out and buy another one, irritating, expensive (usually) but not disastrous.

Cells, of course, do not have a DNA store on the corner to pop out to; if they lose the gene they lose the ability to make that particular protein, definitely debilitating and probably lethal. This is why cells astutely keep the master safe in chromosome and only send a copy out (on a molecule called messenger RNA) to the protein-making factories.

Simple cells such as bacteria have a few thousand protein 'programs' in DNA storage while more complex cells (such as in us) can have tens to hundreds of thousands of genes all neatly filed away.

In order to function, a computer must know where its programs and data are stored. So must a cell. As you might expect by now, both use a similar method.

A computer keeps track of its files by giving them an address, the location in the computer memory or disk where the data is stored. In simple situations, computers use this address directly but for sophisticated manipulations, computers usually use 'pointers' to the address. An example of a pointer is the information "there is a program 3263 ASCII codes long stored in memory starting at location 45,886." The pointer and the program are stored separately. When higher levels of the computer need that particular program they 'access' the pointer

not the program.

Cells, even the least sophisticated of which puts a supercomputer to shame, use this pointer system. When the genetic system wants to make a specific protein, it doesn't interact with the gene directly, it interacts instead with a pointer to the gene, what are called 'control sequences.' And, just as in the computer, the control sequences and the genes are kept at separate locations. The higher levels of the genetic system turn on and off the translation of genes into proteins by interacting with these pointers.

Higher Levels

What are the higher levels like? The details of how they function in the genetic system are not yet in but we know how they work in computers (since we designed them).

Really complex tasks on a computer are handled by large programs in which the example given above would be just one of many thousands of program lines. These large programs, however, are triggered to function by just a few ASCII codes. An example is word processing on an IBM. You (acting as the highest level of control in the computer) type in four ASCII codes, WORD, and the computer becomes a highly sophisticated word processor. That one command triggers a complex series of events to occur and is an example of a high level instruction.

Cells work in a similar way although there are many more levels involved. A protein that interacts with pointers to adjust the production of a protein is called a regulatory protein. There are proteins that interact with pointers to adjust the production of regulatory proteins, proteins that interact with pointers to adjust the production these proteins, proteins that interact with pointers to adjust the production those proteins . . . . on and on, getting higher and higher up the hierarchy all the time.

It is such high level instructions coming down the genetic hierarchy that coordinate the production of thousands of hardware proteins in the functioning of a healthy cell.

A recent development in computer programming is the 'object oriented' method, a simple, if sophisticated example of which is HyperCard on the Macintosh computer. The idea is simple; each program is an 'object' that sends 'messages' to other objects. Each object program can respond to messages such as "the cursor key was pressed" or "the mouse pointer was clicked." The whole collection of program objects work together creating a super program which can, as in the case of the even more sophisticated NeXT computer, take over the complete running of the computer.

These messages are analogous to the proteins (or chemicals made by proteins such as hormones) that pass between cells organizing them into tissues, tissues into organs, and organs into an individual (such as yourself.) The really high level instructions that coordinate each of these integrations is stored in the DNA and they pass down the information hierarchy to the link with the living hardware, the creation of protein.

It's All Programmed!

So in living systems we have two integrated aspects: the interactions of substantial things like proteins along with the interactions of the abstract patterns that are the information and instructions of the genetic system. Life has a vertical, abstract aspect and a horizontal, physical aspect. But 'life' is rather difficult to define and pinpoint at both top and bottom.

At its lowest level, life blends into biochemistry, chemistry and physics. These have a very strong physical aspect, but they also have shape, a simple kind of pattern. Shape is the subject of that branch of mathematics called topology, and topology is a hot topic in all the sciences. Even at these basic levels there are abstract interactions of pattern occurring along with the physical interactions. This abstract aspect is what scientists usually call 'Natural Law.'

At its highest levels life blends into intelligence (the primate brain and, yes, the dolphin) and the spiritual aspects of the human realm. Brain function certainly has a software and hardware aspect although even the bird brain surpasses in many ways our supercomputers by orders of magnitude. (The spiritual aspects alone seem different, almost like software without material hardware.) It would seem that the computer analogy of software and hardware can be applied to almost everything in our universe.

Perhaps if the Apostle's Creed had to be composed in our computerized late twentieth century society it would start with: "I believe in God, the Father Almighty, Creative Programmer of Heaven and Earth …"

41. MAN VS. MACHINE

It started off being irritating. It quickly got irritating *and* insulting.

It started with the lady of gracious voice reading the morning news on the classical radio station—I like to be gently eased back to reality by my clock alarm first thing in the morning.

She was, for her, exhilarated as she announced: the machine had lost; the human had won. World Champion Garry Kasparov had beaten Deep Blue in the first match of their tournament. The announcer's tone radiated pride that the human had beaten off the silicon challenge; the computer had not yet trampled all human dignity. Man could still hold up his head before Machine.

I groused my exasperation with her perspective to her unheeding ears as I dressed.

But worse was to come.

For breakfast with *The New York Times* was a dalliance with indigestion—for now, not only was there the irritating perspective of the radio, there was an added note of insult. This is what had me reaching for the antacid:

"Garry will survive this one," said Frederick Friedel, who is Mr. Kasparov's adviser on computers. Still, Mr. Friedel believes a champion's defeat by a machine is inevitable and, at least metaphorically, cataclysmic. The computer's eventual triumph in chess, he said, will be among just the first intellectual functions in which man's superiority is usurped. "It's going to happen, by the year 2005 or 2010, and we've got to come to grips with it," Mr. Friedel said. "We humans are pathetic, aren't we? We're best at nothing on the planet, except intelligence, and now, even that . . ." (NYT May 4, 1997)

I was fuming at this point: why was the press "spinning" the facts to make the human race look bad, pathetic even.

For to say that this is a *Man vs. Machine* competition is nonsense. It makes for great headlines—I couldn't resist it myself—but it is nonsense.

It would make as much sense to focus on Garry's fingers and proclaim: Thumb-and-Forefinger Duo Beat Computer.

Man vs. Machine is nonsense because both sides of the chess match were being driven by human intelligence: Garry's mind ran his side of the competition: the minds of Deep Blue's designers ran the other.

Kasparov was not challenging a machine: he was confronting a concatenation of human ingenuity and invention that includes electricity, silicon chips, operating systems and clever programs.

As the IBM web site proudly proclaims, *"The latest iteration of the Deep Blue computer is a 32-node IBM RS/6000 SP high-performance computer, which utilizes the new Power Two Super Chip processors (P2SC). Each node of the SP employs a single microchannel card containing 8 dedicated VLSI chess processors, for a total of 256 processors working in tandem. Deep Blue's programming code is written in C and runs under the AIX operating system. The net result is a scalable, highly parallel system capable of calculating 100-200 billions moves within three minutes.... "*

I see nothing to call pathetic here—super-sophisticated or highly-evolved seem to be better terms—for all this is the product of human ingenuity. Computers did not originate electricity, solid-state electronics, operating systems, the C programming language, etc. It was human beings; supposedly *pathetic* human beings, no less.

This chess competition is not Man vs. Machine, rather it is actually Man using traditional methods of playing chess vs. Man using brute-force calculational methods of playing chess.

So why the media hoopla focusing on great machines and threatened human beings?

Well I suppose it is very difficult for media people to think of humans in "child-of-God" terms when they are dealing with "Dad Strangles Daughter" and "Wife Chops Up Husband" all day. After a while it must get them down; they are probably *hoping* that something better will come along to replace us poor, defective humans.

Could the improved being be the computer? They are certainly fast; while Garry contemplates his three moves in one second the computer has examined 199,999,997 more of them.

But speed is not that important. We would think no more, no less of the *Mona Lisa* as an expression of artistic talent if it had taken twenty years to paint it rather than a few weeks. Do we think any less of God's creative genius because He took almost twenty-billion years to create the universe rather than just seven days?

No, just because computers are faster at certain things than humans holds out no hope that they will be *better* than us. This, as we know, will only be accomplished by religion and it's mission to re-creation Man.

Meanwhile, I have a suggestion: God certainly went to a lot of trouble—and it is not over yet—to create something that was His equal—in capacity if not in magnitude.

We have inherited this impulse, not just in the desire to create children (for which we can take only some of the credit) but in the impulse to create machines that can do what we can do (for which we can, collectively, take almost all of the credit).

I definitely would have not have been so irritated if the chess match had been proclaimed as Man vs. Mechanical Child of Man. This would have been much more satisfying.

42. RESOURCEFUL EVOLUTION

It is odd what one can be doing when the 'eureka' moment strikes. I have been chewing and mulling over books and articles for years trying to figure out why the chance-and-accident aspect of modern evolutionary theory was wrong from a scientific point of view. Although much else of the theory is brilliant and insightful, that particular aspect just didn't 'ring' correctly, there were too many loose ends buzzing around (many of which I have talked about in these columns.)

To say, "God did it!" or "Some invisible force is in control," is not an acceptable answer in science. You have to propose specific mechanisms that can be looked for if your theory is to be even considered by the scientific community.

I was walking along 44th Street last May 28th evening on the way to a meeting with friends when it struck, "The concept of random-chance-and-accident is not scientific: it is only saying you haven't figured out how it works yet."

To my mind, the only clear scientific attitude is that each and every process in Nature has very precise laws and principles associated with it and that we can comprehend all of those processes.

Belief in law

Actually, most scientists do believe that all of the phenomena of Nature are governed by laws and principles, and that there are many of them we are, as yet, unaware of. You would be foolish indeed to do 'research' if you didn't believe there was anything left to find!

For instance, if you didn't believe in the total lawfulness of the mechanisms responsible for biologic diversity you would be left in the unenviable position of defending the belief that the lawfulness of Nature tapered off somewhere and that chaotic random-chance-and-accident mechanisms took over.

So it is strange that, while no one is saying that electrons and protons behave in a random-chance-and-accident manner in the formation of simple atoms, they are stating this to be the case for the much more complex rearrangement of the genetic material that occurs in the formation of species, genera etc. during evolution.

If many believers have been guilty of ascribing to the Hand of God what was beyond their comprehension, so have many non-believers been equally guilty of placing all power in the remarkably fortuitous Hand of Chance.

The only Mystery that remains in this material world is what we have not yet understood. That is a lot, but it is possible for us to figure it out eventually.

Resourceful Evolution

This is why it is difficult to accept that in the theory of the Origin of Species—the basic framework of all the biological sciences—there is this insistence that the development and diversification of life from its simple beginnings to the complexity we see today happened by random-chance-and-accident.

This I cannot believe to be the case, nor anyone who aspires to be fully 'scientific.' So I'd like to propose a theory of evolution that addresses some of the deficiencies in the current view.

To distinguish this new theory from the random-chance-and-accident aspects of Darwinian Evolution, I would like to call it Resourceful Evolution. (If you wish to call it 'The Lewis Theory of Evolution' go right ahead, every scientist secretly hopes there will be something to carry his name into the minds of future science students.)

Following the above logic, if evolution does not work by random-chance-and-accident, it must work by some, as yet undiscovered, principles and laws. But, as laws and principles don't work in a vacuum but through material structures, there has to be some cellular mechanism that expresses those principles.

Whatever this mechanism is, it will have to be capable of storing information that can be passed on down the generations and used in the non-random changes we see in the genetic material during evolution. Where could this sort of information be stored?

I'll give you a clue: If you want to keep men in the picture you had better suggest the only material the male passes on to the next generation during reproduction. DNA, you guessed it.

Useless DNA?

If you are at all familiar with molecular genetics you will be aware of the way in which DNA has, so far, been found to function. These are the key points in this understanding.

1. The structure and function of the body is a composite result of the workings of the billions of individual cells.
2. The structure and function of the cell is a composite result of the workings of the thousands of different proteins in each cell.
3. The information on how to make each protein is stored in the DNA which is kept separate from the body of the cell within the nucleus.
4. Within the cell nucleus, the protein-structure information encoded in the DNA is copied onto a similar molecule called 'messenger RNA'. This messenger RNA moves out of the nucleus into the cell body where it is attached to a 'ribosome,' a complex little structure that specializes in making protein. The ribosome reads the information encoded in the messenger RNA and uses it to assemble the correct protein.

Thus the flow of information, as currently understood, is from DNA to protein to cell function to all the thousands of different results we see such as, for example, blue eyes or black skin or big feet.

So, as far as the current theory goes, DNA's sole purpose is to encode information for protein structure. However, within this current theory is a big problem that has really puzzled scientists. This is the strange fact that only a fraction of the information encoded in the DNA ever makes it out of the nucleus and gets used to make protein.

Molecular geneticists find that although very long stretches of DNA are copied into messenger RNA, huge chunks of the information are neatly and precisely snipped out before the messenger RNA is allowed out of the nucleus. It is only the little bits left that are spliced together and then sent out to make protein.

Scientists call the information in the DNA that gets to exit from the nucleus and make protein "exons" (they 'exit'), and the DNA information that is snipped out and are kept in the nucleus "introns" (kept 'in').

Just what is all this snipped out DNA used for if its information never gets to make protein? Most scientists haven't the foggiest idea, although some have come up with ideas such as 'selfish DNA' and 'genetic burden.'

Genetic Resources

Here is where the theory of Resourceful Evolution will depart from current theories. I propose that the snipped out DNA introns is where the information used in organizing evolution is stored.

I would like to call this type of DNA information a 'Genetic Resource' to distinguish it from 'Genetic Data,' the DNA information used by the ribosome for protein manufacture. So there are now two different types of information stored in the DNA: Genetic Resource information in the introns and Genetic Data in the exons. It is this combination of Genetic Resource plus Genetic Data in the DNA that can be considered the basic unit of heredity (the gene).

Using the computer analogy I often use in this column, this 'two different types of information' situation is similar to the way a computer stores data information and instruction information on a magnetic disk.

Both data and instruction information look the same: they are both patterns of magnetic ones and magnetic zeros in specific storage positions. But the same magnetic pattern can have very different meanings to the computer depending upon whether the computer thinks it is a item of data or an instruction. The magnetic pattern '10111' might mean '23' as a data item but as an instruction code it could mean, "Take the number stored in position 1, subtract it from the number in position 2, place the result in position 3 and follow the instruction in position 4."

As you can imagine, if the computer ever makes a mistake and thinks a data item is an instruction item, the dreaded "crash" will rapidly occur. As the cell equivalent of a computer crash is death, this is probably why the introns are carefully snipped out before they can get into the protein-making machinery. They are not 'meaningful' as protein instruction information—which is why most scientists think the introns have no function.

The intron DNA, however, could contain Genetic Resource information such as, "This set of proteins will make dark skin suitable for strong-sunlight climates" or "this set of proteins will build feathers suitable for flight and keeping warm."

Resource Manager

If there is this Genetic Resource information, there has to some structure in the cell that can use the information. It is my guess that this new structure will be found within the cell nucleus, a part of the cell that is not at all well understood in its more complex functions (in simple worms let alone humans.) Even though this structure has not been identified yet, it's a good bet that it will be found to be made of protein and nucleic acid as that's about all that's in the cell nucleus.

If this structure is to use the information stored in the Genetic Resources, we can predict that it will have the ability to perform three basic functions.

1. As the DNA intron information never gets out of the cell nucleus to be 'read' by a ribosome, there must be a structure within the nucleus (equivalent to the ribosome) that can read the Genetic Resource information from the DNA. I'll call this the Genetic Resource Reader. This concept is not really part of current theory although there are already touches of it emerging in studies of the cell nucleus.
2. It is well established scientifically that the genetic material of all life is connected by a chain of relationships. However, the DNA content and the chromosomal structure can be very different in even closely related species. If this is not to be a random process, there must be a structure that can write information into the DNA and chromosome structure. I'll call this the Genetic Resource Writer. In current theory, only brutish techniques such as random mutations and chromosome abnormalities are thought to play this role although there is already some evidence that new genetic material is created by the partial reorganization of previously existing genetic material.
3. There must be a processing structure that can do the actual manipulation and planning functions. This is similar to the function of the Central Processing Unit in a computer. I'll call this structure the Genetic Resource Manager.

How does it do it

Although there are billions of cells in the body, they all work together harmoniously to create a larger whole. Similarly, we can expect that the Genetic Resource Managers in each cell will also work together harmoniously to handle the highly complex functions we expect them to perform. Some of these functions are:

1. The Genetic Resource Manager must be able to collect and store information on the structure, functioning, and environmental success of the organism it is in. This store of information in the Genetic Resources of the DNA I will call the 'Current Image.'
2. The Genetic Resource Manager must be able to 'forward plan.' It must have the capacity to be able to plot out many new design variants that could be developed on the basis of the organism's current structure. Such information I will call a 'Possible Image.' Lest this ability to 'forward plan' seem 'magical and supernatural' to you, I would like to point out the best designers of the bigger, faster and cheaper computers today are the computers themselves.
3. The Genetic Resource Manager must be able to figure out what genetic material would be needed to build a 'working prototype' of one of the Possible Images and be able to figure out what genetic material is missing to complete such a project.

4. The Genetic Resource Manager must then be able to influence the organism in such a way to increase the probability of gaining the missing genetic material during sexual reproduction.

What would be the result of such an impulse in an animal? Simply that the organism would chose, if offered a choice, to reproduce with an individual expressing the desired trait over an individual not possessing that trait.

Biologists call this 'sexual selection' a process that is already well established in biological theory, although it is usually assigned only a minor role. In the "Theory of the Origin of Species through the Mechanisms of Resourceful Evolution," however, it plays a major role.

Now don't you think that sexual attraction is a much more likely thing to have energized the enthusiasm of life than anything random-chance-and-accident?

43. SCIENCE AND THE FAMILY

Even though the situation has changed a lot since the great schism in the 19th century, there is still a lot of tension between the religious and the scientific view of the world. So there is a certain delight when some of this tension is relieved by the scientific world catching onto some of the crucial insights of religion. I experiences such a pleasure in reading "Family Ties," an article 'The Sciences', March 1988. The article is written by Dr. Leonard A. Sagan, an epidemiologist from California who has recently written a book on the same topic, "The Health of Nations: True Causes of Sickness and Well Being" [pub: Basic Books]

The religious insight that I am talking about is actually something most people would answer if you were to ask them, "What has been the most significant factor in your life?" Most people would answer, "My family." All religions put a tremendous emphasis on the family environment. The family, however, doesn't play such an important role in the scientific world view. For example, if you were to ask a technologically oriented person the question "Why do people live a lot longer now than in the middle ages?" They would probably come up with the great changes in hygiene, medical science and nutrition witnessed—at least in our part of the world—in the last century or so.

In this article, however, Dr. Sagan presents impelling evidence that the real answer is the same one religions would suggest, the great changes in the structure and stresses of the family.

In his article, Dr. Sagan, illustrates his mastery of epidemiology (the incidence, distribution and control of infectious diseases) by marshaling the array of statistics about mortality rates before and after the historical change in medical techniques into a surprising conclusion:

"It seems clear that modern medicine, whatever it has done to save or improve individual lives, has had little effect on the overall health of large populations. Still, the fact is that life expectancy has increased spectacularly during the 19th and 20th Centuries. What else might explain such a change. There is no question that sanitation and nutrition, the other factors most often cited, have been beneficial, but neither of these accounts fully for the mystery at hand. It is true that toward the end of the 19th century, improvements in sanitation coincided with a decline in mortality from various infectious diseases in Europe and America, but there is no evidence of a cause and effect relationship. Sanitation worsened in many major cities during the industrial revolution, as the prospect of work drew hordes of immigrants from rural areas. Rotting meat, fish and garbage were heaped in the streets of New York and London and overflowing privies were still far more common than modern toilets in many crowded neighborhoods. Amazingly though, mortality rates from infectious disease fell steadily over the same period."

Dr. Sagan has to look elsewhere, the usual scientific answer does not fit the facts. "It is in a word, impossible to trace the hardiness of modern people directly to improvements in medicine, sanitation or diet. There is an alternative explanation for our increase life expectancy however. One that has less to do with these developments then the changes in our psychological environments. We like to imagine that pre-industrial people endured less stress than we do—that although they may have lacked physical immunities, they spent peaceful days weaving interesting fabrics and singing folk songs. But the psychic stresses of the simple life are, in fact, far greater than those experienced by the most harried modern executive. It is one thing to fret over a tax return or a real estate deal, and quite another to bury one's children, to wonder whether a falls harvest will last through the winter, or to watch one's home wash away in a flood.

"To grow up surrounded by scarcity and ignorance and constant loss—whether in an African village or twentieth century urban slum—is to learn that misery is usually a consequence of forces beyond one's control and, by extension, that individual efforts count for naught. And there is ample evidence that such a sense of helplessness is often associated with apathy, depression and death—whether in laboratory animals or prisoners of war ... Modernization has cushioned most of us against physical, physic and economic disaster. We now take for granted, that we are, in large part, the masters of our own destinies and that in itself leaves us better equipped to fight off disease."

If Dr. Sagan's thesis is true, that it is the psychological change that has dramatically improved people's lives, he can ask the next obvious question. What institution has had the most impact psychologically? Obviously institutions such as fire departments, building codes, social insurance, emergency medical care are important. But more important than any of these institutions by far is the institution of the family.

As Dr. Sagan points out, "No institution has been so changed by modernization as the family. Until the late

18th century, it existed primarily as an economic unit; marriages were arranged for the purpose of preserving property and children were viewed as a cheap source of labor or a hedge against poverty in old age. Beating and whipping were favored as tools for teaching conformity and obedience. Then, during the enlightenment, the standards and goals of child rearing began to change. If children were going to survive in a disorderly and unpredictable world, philosophers began to argue, they could not rely passively on traditional authorities; they needed reasoned judgment and if children were going to develop such judgment, they needed affection and guidance not brute discipline.

It was only gradually, as these ideas took root, that childhood came to be recognized as a special stage of life, and that affection and nurturing replaced obligation and duty as the cohesive forces among family members. During the 19th century as the upper classes came to view children as having needs of their own rather than serving the needs of the family—and, accordingly, started having fewer of them—the infant and child mortality rates began to fall and as the trend towards smaller families spread to the lower social classes, theirs fell too.

"It is unlikely that this is just coincidence, for family size is an excellent predictor of childhood survival even today. Young children of large families continue to suffer more infections, more accidents, and a higher overall mortality rate than the children of small families regardless of social class ... an only child in a poor family has about the same chance of surviving the first year of life as a child who is born into a professional class family but who has four or more siblings. How could this be so? One explanation, supported by various lines of evidence, is that the children of small families are strengthened in every way by the extra nurture that they receive from their parents. During the past 40 years, studies have demonstrated that infants develop poorly, even die, when they are provided food and physical necessities but are deprived of intimate contact by care givers."

Dr. Sagan has brought the family into a central role in his scientific studies and, as I said there's a certain delight in seeing the scientific and religious views coming together. Religion has always known that the spiritual environment of the family is more important than the physical circumstances. But, as Dr. Sagan admits, "we are only beginning to understand the mechanism linking emotional and physical health—the endeavor has of late given rise to a new branch of medicine, known as psycho-neuro-immunology. Thus whatever the connection, the fact stands that the affection and security associated with the modern family are the best available predictors of good health. In the end, it matters little whether sanitation, nutrition and medical care are crude or sophisticated; children who receive consistent love and attention—who grow up in circumstances that foster self-reliance and optimism rather than submission and hopelessness—are better survivors. They are bigger, brighter, more resistant and more resilient. And, as a result they live longer."

What is a of great significant is that this type of scientific work is supporting the religious understanding of the cause of many of the problems we see in American society. Dr. Sagan concludes his article by noting, "It is ironic, in the light of this, that we continue to fret over the quality of our food and the purity of our environment, to spend billions of dollars on medical procedures of no proven value, and to pay so little attention to the recent deterioration of the American family. ... All of this suggests that good health is as much a social and psychological achievement as a physical one—and that the preservation of the family is not so much a moral issue as a medical one. Unless we recognize the medical importance of the family and find ways to stop its deterioration, we may continue to watch our health expenditures rise and our life spans diminish. We will waste precious resources on unnecessary treatments, while ignoring a preventable tragedy."

I think it would be very difficult to find a religious person in America who would disagree with this sentiment. And it is religion, not science, that has the greatest insights into the factors that effect the quality of family life.

44. AIDS: Scourge of the 20th, Healer of the 21st?

God has been getting a bad rap recently and I wanted to do my bit to set the record straight. You see the notion is being spread around that God has sent AIDS as a curse to blight the lives of people following certain lifestyles. I have even heard the same sentiment from not-so-few fellow Unificationists.

This is really unfair. Anyone who knows anything about God should know that this is not *at all* the way He works.

And as for the Unificationists, they really should know better as the Principle of Creation is quite unequivocal; God cannot create anything that is inherently evil. The Principle of Restoration is that God's ideal is repentance

and change, not killing people off before they have a chance to come to their senses. Only the other guy could possibly be happy about people going to spirit world filled with disease and despair. And does it really make sense that God is out to curse the hemophiliac who caught AIDS through a blood transfusion and the nurse who got it by pricking her finger with an infected needle?

The truth is, as usual, a little more subtle and a lot less Old Testament.

God did create the basic concept of the AIDS virus, not as a curse but as one of the many powerful forces in nature. So in one sense, God does curse people with AIDS but only in the same way that He can be said to curse people with broken bones whose lifestyle includes jumping off cliffs.

There are very real spiritual consequences that occur from following various lifestyles, to be sure, but the topic is a specific physical, not spiritual, phenomenon: the AIDS epidemic.

Like the power locked within the atomic nucleus, the HIV virus that causes AIDS is a powerful force of nature. The hydrogen bomb will vaporize the most righteous and prayerful along with the most abject and miserable sinner. The power in the atom, however, is not a curse from God.

Atomic fusion has a fabulous potential to save us from—as *The Economist* coined it—the "saddamnation" of dependence on the soon-to-be-exhausted resource of oil—there is more power available from the top inch of water in Lake Superior than all of the oil there ever was (or ever will be).

Like the other great powers that God has placed in nature, it would make theological sense that the AIDS virus should also have a potential for good. Just in time for metaphysical consistency, it has recently been discovered that this virus might, when properly tamed, be one of the most powerful forces for healing in 21st century medicine.

The problem-looking-for-a-solution is that a great deal of suffering in the world is caused by genetic defects. To see how the AIDS virus could solve this problem, we need a simple overview of healthy genetics, defective genetics and the sneaky ways of the virus.

Genetics

This new technique has become possible because of the advances in our understanding of how living things work. You started life when a sperm cell from your father and an egg cell from your mother united together forming a cell called a zygote. It didn't look at all like you—in fact it looked more like a tiny blob of cloudy jello. However, that cell contained within itself all the information it needed to be able to turn itself and a heap of fragrant food into you with a rather large amount of malodorous waste on the side.

The information needed to accomplish this commonplace miracle is stored in DNA, a remarkable chemical that is used by the body in a way remarkably similar to the way my computer stores this article I am writing on a floppy disk.

In an oft-used analogy, the simplest bit of information on DNA can be likened to the letters of the alphabet. These are combined into words, and words are combined into sentences. In this analogy, the HIV virus contains just a one sentence instruction: Make more bits of the virus, assemble them and release mature virus from the cell.

The 'words' of information in the DNA are the instructions on how to make the protein 'machine tools' that do all the living that living things do.

Construction Set

Take a simple machine that can pick up four plastic rods from a box on the left, weld them together and then place the resulting frame in a box on the right to wait for the attentions of another.

The machine is one of ten thousand varieties whose activity collectively transforms raw materials into a myriad forms—frame houses, skyscrapers, machine tool factories as well as simple machines such as themselves.

Shrink the machines ten thousandfold. Shrink them again another one thousand. This is actually the goal of nanotechnology, the fabrication of complex functional machines too small to see. Progress has been made and working gears and cogs have already been fabricated that are only one hundred thousandth of an inch across.

Nature, as usual, got there first and has already accomplished the ultimate in machine tool miniaturization with the proteins in which the 'cogs and gears' are single atoms.

The DNA contains all the information needed to construct every one of the protein machine tools needed by the cell, the organ, the whole body during every stage of its growth and development. The 'word' of instruction stored in DNA corresponding to a single protein is called a gene; each gene makes one specific type of protein machine tool.

Current estimates are that it takes the activity of about one hundred thousand such different proteins to run all the living done by a human body.

Genetic Defects

That's a lot of information and it has to be copied in its entirety during the construction of each one of the trillions of cells in the body, including the egg and sperm cells.

And occasionally this information gets corrupted in some way, there is a mutation, and a faulty gene results. As a faulty gene is likely to instruct the making of a faulty protein the potential for disruption becomes clear.

For instance, the disease of sickle-cell anemia, a painful and sometimes fatal syndrome, is caused by just one

faulty machine tool, the protein that carries oxygen in the blood from the lungs to the rest of the body. The fault is very small—just one 'letter' in the DNA is wrong—but it has a devastating effect on the ability of hemoglobin to do its job properly.

It would seem that a potential cure for this disease would be to replace the faulty gene with a functional gene copied from someone without the disease.

Gene Replacement

An excellent overview of the possibility of such 'gene replacement' can be found in "Gene Therapy" in the October 1990 issue of *Scientific American* which kicks off with the chilling report that:

"One infant in every hundred is born with a serious genetic defect. Usually the damage becomes evident in childhood. All too often it gives rise to physical or mental abnormalities, pain and early death. Of the more than 4,000 known inherited disorders, most lack fully effective therapies."

Clearly God would be most thoughtless if He had not provided a way to correct this wear-and-tear that is gradually accumulating in the human genetic makeup.

It just so happens, to get back to the original topic, that one of the most promising techniques to do genetic therapy effectively involves the HIV virus, the agent of the current AIDS epidemic.

You see, the problem is not finding a functional gene; there are billions of them in every pint of donated blood. (Creating one from scratch, however, is way, way beyond current capabilities.) The problem is getting the gene into the proper place in the cell control machinery so that it can do its job properly.

You can probably think of the simplest way; put the gene on a tiny bullet and shoot it into the cell with the problem. It's been tried and the gene does get in the cell. But, because it's not in the proper place, it quickly gets broken down into raw materials.

A better way was offered by ordinary viruses. They get into cells and their genes take over the cell to make more virus—no way do they get broken down. The problem here is that the gene stays with the virus; it does not get incorporated into the cell control machinery where it can do its job properly.

Retro Virus

This is where the rather odd retro-viruses come in, and HIV is one of them, with the prospects offered by their unique way of functioning. Instead of having DNA genes as do all the other viruses, bacteria, plants and animals, they have RNA, a chemical cousin to DNA which plays the role of a 'messenger gene' in regular organisms.

The way everything else in the living universe functions is that the master DNA genes are kept separate from the hurly-burly manufacturing areas of the cell. The information on the master DNA genes is copied onto messenger genes made of RNA. It is these that are sent to the industrial areas as instructions for the construction of the protein machine tools.

The retro-virus, on the other hand, has no master genes, just a collection of messenger genes. These viruses, however, have a trick up their sleeves. They do something that no other living organism does.

Packed neatly inside the retro-virus along with the messenger genes is a set of unique proteins whose sole function is to copy the information from the messenger genes onto master DNA genes and then splice them into their proper place in the cell control complex.

It is this reverse flow of information that earned these nasty little creatures their title, retro-viruses.

This retro trick places the virus information onto master genes right in the midst of the cell control center. Blithely unaware of this intrusion of foreign DNA, the cell goes about reading master genes to make messenger genes and proteins as usual. Unfortunately, instead of running the life of the cell, the output of all the activity is now virus messenger genes, some of which get packed into the next generation while the rest of them instruct the cell's industrial plant to make the unique retro-proteins and the proteins of the virus coat. The cell, following yet more instructions, packs all the bits together into mature viruses which are then released to find and take over other cells.

Sneaky is not the word for it.

The poor cell is so diverted, perhaps even killed, that it is unable to do its normal function which, for the T-cell, the residence preferred by HIV, is the command of the immune system. With its defense system disabled, the body succumbs to opportunistic infections, invading microorganisms that it usually shrugs off with ease. Thus the Acquired Immune Deficiency Syndrome, the dreadful AIDS.

Hope in the Dark

The HIV virus, however, is an agent of hope because, in its turn, it can be infiltrated and used for a purpose larger than itself (which, as we know, is one of God's preferred lifestyles). The techniques are already emerging to create a therapeutic retro-virus by the manipulations of genetic engineering so that it now possesses these desirable traits:

* Packed inside the virus coat which does all the work of gaining access to the cell is a functional messenger gene. In the case of sickle cell anemia, it would be the correct messenger gene for healthy hemoglobin.

* The virus dutifully infects a cell and copies all the message genes it contains into master DNA genes and inserts them into the cell control center. The cell now has a functional gene for making healthy hemoglobin. End

of problem (at least for that cell.)

* The virus, however, no longer has the information necessary to construct more viruses so there is no chain-reaction infection and disabling of the cell. Dead end for the virus but I doubt anyone will shed a tear.

As I intimated at the start, this is still a hope for 21st century medicine as the techniques are still in the laboratories and experimental rats and mice. And there are many significant hurdles to overcome.

Yet the potential is clearly there. Perhaps one day, the scourge of the late 20th century will become the means to cure each one of those 4,000 genetic defects. And it will be almost as simple as catching the flu.

45. MIND OVER MATTER

It had to happen sometime. My dentist had been telling me for over a year that it had to come out. Then that weekend the impacted molar decided to let me know that it too thought that it had to come out. I pledged to myself that come Monday, I would do what had to be done.

Tuesday morning I was in the chair. Bustling around me the gentle dentist kindly listed one by one in rapid succession all the things that could go wrong and how to cope with the dreadful consequences —put a used tea bag over it if it will not stop bleeding and press firmly. Desperately I tried to catch the next instruction as I frantically thought of having no tea bags at home except peppermint and would they be sufficient to Save My Life?

I will say no more, suffice to say it was better and worse than I imagined. "Oh dear, it looks like it's going to be a 'Dry Socket'" he intoned as he scratched around in my bloodied mouth. Praise the Lord that I couldn't remember exactly which of one of the horrors earlier listed he was preparing me to endure. "See you next week," he soothed as I wobbled out the door clutching an icebag to my benumbed jaw.

That evening, as I laid in my codeine befuddled semi-slumber, I bent my thought towards the gash in my gums. Mentally—I didn't dare do it with my tongue as I clearly remembered the admonition Do Not Disturb the Clot—I felt around in there. Warming up to feel of it, I sent it waves of thought: "Don't be a Dry Socket, be moist and happy." I mentally caressed the clot: "Don't be disturbed, be solid and firm." I encouraged the little cells to multiply and fill the hole with new gum, I scurried with the scavenger cells as they cleaned up the mess.

Relation of Emotions to Cancer

Emotional Response 3 Months after Operation	AFTER 10 YEARS	
	Alive	Dead
DENIAL	50%	50%
FIGHTING SPIRIT	66%	34%
STOIC ACCEPTANCE	23%	77%
HOPELESSNESS	20%	80%

SOURCE: THE NEW YORK TIMES/THE LANCET

I was so inspired with my new-found deity-to-cells that I spent time each morning and night with them, encouraging and exhorting them to greater efforts. It seemed to work as the swelling was minimal and the dreadful pain I had been warned against never materialized. Back in the chair again a week later, the dear man peeked in and declared me healed. "No dry socket?" I mumbled. "No," he chuckled, "It's almost completely healed."

I left the office completely convinced that I had thought myself well.

Biochemistry is king

Such a concept does not sit well with current scientific thinking at all as everything supposedly can be explained by the complex chemical interactions within living things: Biochemistry is king. In this way of thinking, 'mind' is something that is a result of physical processes, created by the pulse and flow of electricity within the brain. It is an effect, not a cause.

So the question is, am I weird or is current scientific thought?

Well, according to some recent work reported in the *Science Times* section of *The New York Times*, I might not be too far off base.

In the October 22, 1989 article "Strong emotional response to disease may bolster patient's immune system," Daniel Goleman discusses a report in *The Lancet* journal of medicine from England about a study that examined how emotions effect the survival of patients who have been treated for breast cancer.

The opening paragraph, the lede in journalistic parlance, summarizes (as it should) the situation: "Evidence appears to be mounting of the specific links between people's emotions, the body's immune defenses and the course of serious disease." The following diagram accompanied the article:

Such work—and such findings—are way out on the fringe of modern science. As might be expected, there is

a disclaimer (rather like the ones that dreadful HSA Legal Department is always foisting on me, such is our cross we willingly bear.) "While the scientists point out that the research should be interpreted with caution because of the small number of women studied, they propose that mental attitudes should be included in reckoning the medical prognosis of women with breast cancer. 'Whether mental attitudes can be changed and whether such changes improves survival,' the report says, 'are questions worthy of further study.' "

Naturally, things are not quite so simple, and the article goes on to discuss findings that attitudes do not seem to influence the course of advanced cancer. The key point is that it is clear that sometimes the mind can have a very powerful effect on the course of disease.

The role of Spirit

Now if you are a 'believer,' this will come as no surprise to you at all. The surprise is probably more in the form of "what took them so long."

After all, if you have witnessed spiritual healings—whether of the dramatic crutch-abandoning, Hallelujah variety or the quiet, personal victory over the odds—you cannot doubt that the spirit is master of the flesh.

It is important to note that in Unificationism, clear distinction is made between the spiritual and physical aspects of the mind. The spiritual aspect of the mind is expressed through the physical aspect, it has nothing directly to do with matter—the brain and it is not amenable to scientific study with physical tools.

Now this is not to say that when all those thoughtful scientists who appeared on the PBS program "The Brain" relinquish their protoplasmic housing and start their explorations of the eternal world of the spirit that they will not make equally dramatic advances in their understanding of the spirit mind using spiritual tools. They probably will, after all they have to do something for the rest of eternity. But for now we are restricted to understanding the physical aspect of the mind.

The physical mind of a human being is similar, though more sophisticated, to the mind of a chimp or (that symbol of the 60s) the dolphin. It has two aspects—the invisible part, which roughly corresponds to the instinct, and the visible part which is the brain in all of its convolexity (a word I just made up that cleverly combines 'convoluted' with 'complexity'. I do hope William Safire will one day discuss this useful term in the New York Times Magazine. Such are the goals of life.)

This view is not to be confused with the dualistic view of mind and matter as very different elements of reality —in Unificationism the invisible and visible elements are simply aspects of the same thing.

Imagine the following sequence: Dick creates a thought in his mind—"Do you have a subway token?." The immaterial, internal content is the question, the material, external form is (although no one is really sure about this) a pattern of electric current in the cells of the brain. The internal content remains the same as the external form is first transformed into a pattern of muscular contractions in the mouth and throat then into a pattern of waves, first in the air and then in the fluid in Jane's inner ear, where it is transformed into a pattern of nerve impulses which arrive in the brain where the internal content—"Do you have a subway token?"—registers in Jane's mind. She formulates her reply—"Buy your own"—which is transmitted back in the same way.

The invisible aspect of the mind is not something strange that is imposed from outside, it is built up from smaller parts just as everything else is. The smallest material fragments—the elementary particles, atoms and molecules—have an invisible aspect or character that, in relationship to the Principle (or Logos) that God created to run His universe, experience a force that makes them behave in the appropriate fashion. In science we would describe this as 'lawful behavior' and the part of the Principle responsible for such behavior, 'Natural Law.'

A cell—a very complex assembly of these smaller subunits—also has an internal character which relates to the Principle in a much more complex way, experiencing a force that guides the subtle and responsive behavior of the cell. In science this is called 'life' and in Unification Thought this is called 'protoconsciousness,' the simple mind of a cell. If you ever watched an amoebae under a microscope, you might call it's behavior 'mindless.' But you try to develop a blob of jello that has sensor mechanisms, a built in mini-computer that would shame a IBM-PC and can duplicated itself [ad infinitum] and you will see that there is quite a sophisticated intelligence embedded there.

When cells are integrated into higher levels of complexity, the force that the Principle exerts is correspondingly more subtle and complex—the force we call instinct. This force of Principle is quite irresistible. With one exception, nothing can go against it. A cow can no more decide not to be a cow than a mountain can be, or want to be, a molehill.

The exception is us. The spiritual aspect to our mind is boss—it can override the instinct. If the spiritual mind is healthy, no problem, they are designed to interface (to use high-tech computer lingo) beautifully. However, when the spiritual mind is diseased, it can cause a lot of problems. As it does.

So in the search for artificial intelligence, as we learn to make smaller and faster and better, we can aspire to recreate in silicon (though there are many other contenders) the mind of the amoebae, the cockroach, the pigeon, the chimp. But the mind of man, the mind of woman, are forever beyond our physical creation as they partially reside in the realm of the spirit. Mind you, there's always spiritual robots to make and then to tinker with.

46. A UNIVERSE THINKING ABOUT ITSELF

I like the word 'oxymoron' (ox-see-more-on). It makes me think of a hyperventilating idiot but actually means an incongruous grouping of contradictory words that inherently denies itself. One of the best ones I ever came across was "Long Island Expressway" (submitted to a [National Review] competition) but it probably only reveals its full flavor to those long suffering souls who commute via this sluggish way into Manhattan each day.

Well, if ever there was a scientific discipline that deserved the dubious accolade of 'oxymoron' it surely must be neuroscience.

You might be tempted to think the same as well after reading '3-pound Universe,' a recently published book that offers a guided tour to all the recent advances in brain science. ('3-pound Universe', by Judith Hooper and Dick Teresi, 1986, Macmillian Publishing Company, New York.)

I hasten to add that the above appellation was not earned because the book is about humdrum, treadmill science. Far from it—it was a great book to read and I highly recommend it. If that had been the case, no problem. Quite the contrary, the content of the book is so fascinating and compelling that my own little "three pound universe" could hardly put it down.

And therein lies the oxymoronic content of neuroscience: it just isn't the sort of brilliance and insight that one would expect from a soup of complex chemicals quivering from one subtle state to another.

The Brain Age

The book declares, "This is the Brain age. The 1930s and 1940s were the golden age of physics. The next decade saw the flowering of molecular biology. . . But the great frontier of the 1980s is neuroscience."

Like these other sciences, recent advances in neuroscience have all the hallmarks of brilliant, creative minds at work.

Yet, early in the book the authors report the responses of scientists to the "ancient riddle": "Is the mind the same as the brain?"

"Many said, [Of course], where else could the mind be? Others said the question was unanswerable. Some changed the subject to neuroactive peptides."

Those scientists should lift up their eyes, if only high enough to read the book about themselves, and realize that there is more to the human mind than any conceivable mix of 'neuroactive peptides'.

The book was interesting precisely because it didn't dodge these awkward questions. In fact the book starts off (after a foreword by master-materialist Isaac Asimov) with the question of how modern science might view the Saul's conversion experience on the road to Damascus. "Hmmm . . . a grand mal seizure with interictal spiking . . . Disorientation, paranoid ideation, auditory hallucinations . . . " perhaps?

Matter only

This oxymoronic desire of the neuroscientist's brilliant brain which seeks to demean itself boils down to ideology which is, to quote those authors again, "the central gospel of modern neuroscience: that mental states come down to bodily events and there is but one substance in the universe—matter."

The book reviews some of the brain-research results that seem, at first glance, to show that the scientists have done it: [proved] that the mind is the brain. Findings such as:

* It seems that you are shy or dominant, antisocial, alcoholic, suicidal, or predisposed to murder largely because of the chemicals in your brain.

* With a new generation of "designer" drugs, pharmacologists are proving that a world view can be quickly changed by a molecule.

* Memory depends on very specific bits of gray matter. Ditto for language, the recognition of familiar faces, the ability to account and read and many other higher functions. Wipe out one part of the brain and a person speaks fluent gibberish; remove another and he no longer knows his own brother on sight.

* Twenty years of research on "split brain" patients (whose two cerebral hemispheres have been surgically disconnected) leave us with the disconcerting possibility that a person can possess two minds in one body.

* Your brain contains pain and pleasure centers as well as control switches. When a mild electrical current is delivered to their "pleasure centers," paranoid, catatonic, or violent mental patients are sometimes converted (temporarily, anyway) into well-adjusted people.

The debate continues

However, for all this effort, the final proof is not in. As one scientist is quoted as stating:

"A totally nonideological science would have to stand up and say, 'We've bought the most exquisite techniques to bear on the organization and function of the human nervous system. And we're obliged to report to you that the richest psychological dimensions of human life are not explicable in terms of the biochemistry and physiology as we know them to date.' "

As Hooper and Teresi report, "Even in the land of dose-response curves and 'tight experimental controls,' we found that many have taken the road of reductionism and met a dead end."

It is absolutely fascinating to read of the various scientists they met "who quoted the *Bhagavad-Gita*, Carlos Castaneda, Plato, Aristotle, St. John of the Cross, and *The Tibetan Book of the Dead*." There are also intriguing interviews with "a biological psychiatrist who has embraced charismatic, speaking-in-tongues Christianity; a sleep researcher-turned-phenomenologist who thinks the outside world may be an unverified dream; a no-nonsense M. D. who has empirical evidence of life after death…"

Mind and matter

The materialistic model—that the mind is a product of the biochemical processes occurring in the brain—just does not sit well with the reality we experience. Another way of looking at this system says that the mind and brain are separate entities that hook up in some way. Descartes (1596-1650) founded this idea in modern thought, the mind is outside the body and independent of it, but interacts with it (through the pineal gland he speculated). And of course there are those really far-out thinkers who see everything as thought alone.

The Divine Principle presents a little explored alternative to these points of view: That everything has mind and body aspects, you just can't have one without the other. According to this view, the internal 'mind' aspect is reflected in the external 'body' aspect. And this applies on every level. The shape and form that atoms and molecules take are a reflection of the invisible natural laws; the activities of cells are a reflection of the invisible laws and the intangible quality of life.

In the brain the same principle applies, you cannot have thought without the pulsing of neurons etc.—and you can't alter the externals without affecting the internals (as just one glass of wine will convince.) So the mind and brain are not separate things and one does not generate the other; they are the same thing, just different aspects thereof.

Enough is enough, let's now give our "Three-pound Universe" a respite from the contortions of trying to examine itself .....

47. BIG FAMILY: SPACE NEEDED

Philosophical insights can come in strange places, even in a lavish, choreographed dance number from a Hollywood musical (I think it was "Seven Brides for Seven Brothers"). While whirling madly, the chorus whoops out all the many good reasons why "The Farmers and the Cowboys Should be Friends." Although they would be a challenge to put to music, there are also many good reasons why "The Scientists and the Religionists Should be Friends."

One of these reasons for friendship became quite apparent to me the other day as I was reading a rather pessimistic article in National Geographic about the population explosion which worried that we "may be nearing full occupancy of the earth's arable lands." There is reason for concern, at the current rate the world's population will double over the next eighty years. While technology can do marvels in providing the amenities needed for "life, liberty and the pursuit of happiness" for an increasing number of people—and who really knows how many people a healthy world society could support—one thing is clear, that number is a finite number. At some point in the future, people living on this planet are going to have to limit the number of children they have.

Big Families

But some people, especially religious people, want to have lots of kids. Many religions and cultures encourage big families. All religions give Man a special place in the scheme of things and some even go so far as to suggest that God specifically created the universe to be the home for Man, His children. If He is that interested in people, then God would probably also like a big family as well.

On this planet, however, this impulse to have large families is going to have to be repressed at some point because if each couple has only four children (doubling each generation) then it would only take another 30 generations for the population of this planet to reach a billion billion. At that point the whole earth, including the oceans, would be filled with people the way Manhattan is today. This would be uncomfortable, to say the least, as there wouldn't even be a Central Park to escape to on weekends.

Plenty of Room

God was not so shortsighted, however, in His creation of the Universe as to leave no room for expansion. The stars in the night sky are not just there for decoration, they are up there for a purpose.

The universe is huge beyond our capacity to imagine. In our galaxy alone there are about 100 billion suns, a good proportion of which are very similar to our own maker (or breaker) of summer vacations, our very own star, the Sun. Current theories about the formation of the solar system imply that the formation of planets is a normal, expected consequence of the ways in which all stars form. Most, if not all stars, can be expected to have planets even though nobody has actually been able to find any yet as such detection would require the sensitivity of the orbiting Hubble Space Telescope which will one day soon ascend on the Space Shuttle.

But as a rough guess, we can assume that one percent of the stars have planets similar enough to earth to provide the raw material for a habitable environment. We can expect that most of them will need a little work—such as creating an oxygen atmosphere—but these are technical details of a process that has already been given

the name 'terraforming.'

So our galaxy—the Milky Way Galaxy—has perhaps one billion planets with the potential to be a home for people.

There are at least 100 billion other galaxies out there in the part of the universe that has been examined so far by our largest telescopes. So as a rough guess we can speculate that in the known universe there are about a hundred billion billion planets similar to earth.

If we assume that a healthy (in comparison to our rather sick) society can provide a suitable environment for ten billion people to enjoy on a planet like ours, then the bit of the universe we know about could support a population of a thousand billion billion billion people—quite a big family, even from God's viewpoint.

So the problem is not space, there is plenty of room for the human family to expand in.

Speed Limit

Contemporary wisdom, however, says that there is one big problem facing this cosmic "Go Up, Young Man" expansion of the human race. Our universe has a speed limit imposed by the equations of Relativity discovered by Einstein. These equations convincingly show why nothing with mass can ever move at the same speed that light travels, and can certainly never exceed that speed.

In our daily lives this limit is not noticeable as it is about 670,000,000 miles /hour. That's fast enough to satisfy even a New Yorker in getting around in the neighborhood. It would only take 16 minutes at that speed to take a sightseeing trip to the Sun and back again (assuming you didn't melt when you got there.) This is quite fast enough to allow us to get around the solar system to the other planets, none of which is particularly suited to the outdoor life but could be home to the kind of person who enjoys malls and other integrated indoor lifestyles.

Once we get outside our own solar system, however, we are faced with the overwhelming vastness of the universe. There might be a lot of other suns out there, but they are not very convenient for travel.

Even at light speed it takes 50 months of traveling to get Proxima Centauri, the nearest star and 32 thousand years just to get to the center of our galaxy (we're about 2/3rds of the way out). Beyond our galaxy travel really gets tedious, even First Class, taking over 2 million years to get to Andromeda, the nearest galaxy and over 10 billion years to the truly far out ones.

Either the religious insight into the purpose of all that real estate in the night sky is unrealistic or God must have included in His plans some other way of getting around the universe that circumvents (but never breaks) the lawful speed limit.

Tunnel Traffic

Well it seems there just might be a way around these apparent restrictions on travel. Not only did Einstein find out about the speed limit, he also provided the theoretical framework that just might show how to get around the limit. Einstein showed that gravity—the apparent force that keeps us firmly grounded and also keeps the planets, suns and galaxies in their place—is the result of a curvature in the four dimensional space-time in which we exist. We normally think of space and time as being a featureless background in which things—such as our selves—move around and exist in.

Einstein showed clearly (at least to people who grasp his math) that this is not so, the background space-time has a structure. The basic concept is simple, matter causes space-time to get curved, the more material there is, the more it gets curved. What we perceive as gravity is actually this curvature. The math is exquisitely complicated and subtle (after all, he didn't get famous for nothing) but overall the effect is very similar to that in a much easier situation to understand, that of a thin rubber band.

In our space-time there are four directions (and their reverse) forward (backward), left (right), up (down) and future (past). In the rubber band things are much simpler, there is just forwards (or backwards)—it's a one dimensional situation. Left alone, the rubber band is flat. Put a small weight on it and it gets dented. Put a big weight on it and it gets really dented. The key point to notice here, is that this denting is not taking place in the one dimension of the band, it is in a higher dimension, in this case, down.

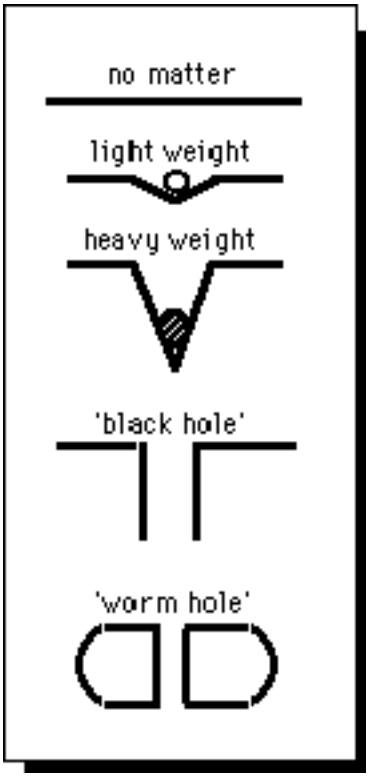
The curving of our four dimensional reality by material is very similar, space-time dents into a (difficult to imagine, but just as real) higher dimension that is not one of the familiar four. If you call this higher dimension 'hyperspace' as they do in 'Star Wars' you'll not be that far off the track. This dimension is just as real to a modern physicist as the four familiar ones of time and space.

Put a really heavy weight on the rubber band and it breaks, you get a hole. A similar situation happens in space-time. There can be so much material in one place that space-time gets infinitely curved , it sort of breaks leaving a hole. This situation is called a 'black hole' and they are created in nature during a supernova, the death throe of a large, elderly star. In this immense convulsion, material twice as much as our Sun gets squeezed into a space the size of Manhattan (sorry to keep using my town as an example, but if you lived here you'd know how difficult it is to believe that there is any other 'there' out there.)

In the rubber band, two such holes could join up creating a shortcut through the higher dimension that would be much shorter than having to go all the way around the rubber band. In a similar way, it is theoretically possible for two such holes in our space-time to join up, connecting two regions that in regular space-time are billions of miles apart. These are called 'wormholes' in the scientific literature (for no really good reason unless it

is an attempt by another New Yorker to refer indirectly to the Big Apple.)

Using these wormholes as shortcuts, travel time to any part of the universe could be quick and convenient. They could also provide a great improvement on the New York subway system, for that matter.



Theoretically Sound

These wormholes are taken seriously by contemporary physicists, prompting a report (Nov. 22, 1988) in the science section of The New York Times to speculate, "Could some advanced civilization devise a tunnel that would open shortcuts through space between distant regions of the universe or through time into the past?... The question of whether or not wormholes could be used for cosmic voyages ... hangs on whether or not a theoretical relationship can be violated. If this relationship, which relates to the subtleties of quantum theory, can be violated—and Dr. Thorne [an eminent astrophysicist] believes this is possible—then wormholes could hypothetically be used for travel."

Of course, there are technical difficulties. Getting into a Black Hole is much easier than getting out of one—even light can't do that—but scientists are already thinking about how to keep a Hole open once they are created. In the same article is the report that, "To keep the wormhole from snapping shut the instant it was created, the researchers suggested application of an arcane quantum effect of the electromagnetic in the wormhole that might be induced by putting plates of gold or copper at opposite ends of the wormhole." Sounds a bit like the Time Machine that Hollywood built for H. G. Well's Victorian time traveler—but this is in the official publication of the American Physical Society.

This new way of travel would be intimately tied up with our ability to manipulate gravity. It is a humbling thought to realize that our much vaunted modern science stands in relationship to gravity in much the same position as the science of the ancient Greeks stood to electricity—they knew it was there (they named it for us) as does anyone who has been bothered by static cling, but they had no power to manipulate it into doing anything useful.

Probably the first technological hurdle to creating wormhole subways throughout the universe will be the manufacture of black holes. These can theoretically come in a range of sizes, from the truly immense ones that nature makes all the way down to black holes smaller than an atom that weigh as much as Mount Everest.

Whatever the technological challenge, one of the good reasons why "The Scientists and the Religionists Should be Friends" is that religion is right in there with an encouraging, "There must be a way to do it, we just have to find it." This is helpful because as any scientist will testify, you never stumble upon the right answers unless you are asking the right sorts of questions.

So perhaps in the future when such technology has been perfected and the earth is packed with people and life is tame—the greatest adventure will be for you and your wife to take off for a brand new planet and get to play Adam and Eve—hopefully without messing up.

48. THE STARS BLAZE FORTH THE GLORY OF YOUR BIRTH

Poor Ronald Reagan! It seems our esteemed President is having to weather storm after storm these days—such a difference from those early triumphant years. Hardly anybody seems to like him these days, although I have a feeling that by this time next year we will all miss him sorely. The latest goad with which to torment him is that he and Nancy are being mocked for taking cues from astrology.

We can assume that much of this mockery derives from a politically motivated desire to discredit. As this paper is supposed to be mute about political issues, I will pass over this source of criticism.

There are, however, at least two other perspectives that cast doubt on the wisdom of heeding astrology:

Science and Religion. To my mind, from a certain perspective, these rather strange bedfellows have much the same comment to make about astrology. Let's take a look at the religious perspective first.

Religion and Astrology

An almost universal concept in higher religions is that God created man to be the ruler of the physical world. It does not make sense, therefore, that man would be objective to, and ruled by, the planets. The idea of planetary influence has to be thrown out for this reason.

Another of the basic ideas in astrology that has more going for it, is that you can predict much about the characteristics a person from the positions of the planets at the moment of their birth. This actually makes some sense, even though, as you will see, we will have to turn some concepts upside down.

A human being is created in the image of God while the rest of the universe is created as a partial reflection of God. Man is not just physical material, he also has a spirit. Just as the physical body is constructed in the womb, the Divine Principle teaches that the spirit is also coming together during this time, and at the moment of birth, with the first breath, the spirit completes itself and becomes eternal.

So here we have a situation where, at the moment of birth, a human being becomes an eternal being, a truly human being, reflecting God. God's image is fully expressed there (in potential, actually, but that's another topic) at that moment. But at that same moment, the rest of the universe is also a (partial) reflection of God's image. This means that the universe is also a partial reflection of the child at the moment when the child first becomes like God. We can speculate that people throughout the ages noticed the correlation between the planets and birth and went on to develop the familiar theories to explain it, Voila! Astrology.

While it does not make sense to say that the planets 'influence' the newborn child, it does make sense to say that the universe is proclaiming the special qualities of the child born at that moment. There is a sound theological reason for this: The parental heart of God wants to celebrate the birth of His children—wouldn't you have designed things that way if you were a cosmic "mush-heart" parent?

That's why you can proudly say that the planets proclaimed the glory of your birth, just as they have for everyone else.

If religion can give a reason and purpose for the phenomenon, perhaps science can come up with an explanation for it, a better one than "we are ruled by the planets."

Science and Astrology

Our contemporary science seems to have little good to say about astrology. The central tenet of astrology is that the positions of the planets influence human behavior. In our science, the only interaction that both humans and planets respond to is gravitation. The gravitational forces of the planets on us, however, are extremely small. If the planets did influence us through the gravitational force, the much greater gravitational effects of local mountains and oceans could then be expected to have an even greater influence. If this were so, we would expect that people would have noticed it and developed 'geology' instead of astrology—then the science of land masses would have had to adopt another name, perhaps geonomy.

This is not to say, however, that science proves that astrology is bunk. Science can state that the astrologers have got their theories that explain their observations all wrong (unless there is some totally unknown interaction yet to be discovered by science—unlikely, but not impossible.) A good historical illustration of this situation is that while the theories of the alchemists were way off, their descriptions of how one material could be transformed into another became the foundations of modern chemistry.

Unfortunately, I am not aware of any scientific study of the relationship between the predictions of astrology and what actually transpires. One thing is apparent, however, and that is that many people in many different cultures have placed a lot of confidence in the capabilities of astrology over thousands of years. As you are probably aware, you are not alone, Nancy.

So let's give all these people the benefit of the doubt and assume that astrology is describing a real phenomenon (even though its theories as to how it works might be wrong) and that the positions of the planets at birth do correlate with peoples' dispositions and fortunes. Assuming this, is there anything in modern science that could begin to encompass and explain the phenomenon?

Least Action

Even though we have gone through a tremendous revolution in physics this century, most scientists still think in terms of 19th century concepts of particles and forces. Astrology could never fit into that structure. There is, however, a way of thinking that is gaining hold within the mainstream of modern science that can encompass the likes of astrology. This is the "Principle of Least Action," which—even though it has only gained greater acceptance in this century because of its perfect fit with quantum mechanics—first appeared in the seventeenth century as an alternative formulation of Newton's laws of motion.

This action principle (or 'action formulation' as the scientists put it) is universally applicable: It applies to every system studied by science—classical physics, quantum mechanics and relativity included. An excellent overview of the action principle in modern science can be found in the chapter "Where the Action is Not" in the book "Fearful Symmetry: The Search for Beauty in Modern Physics" (Macmillan Pub.) by Dr. Anthony Zee, the

one I mentioned in my April column. Incidentally, the formula describing the workings of the whole universe in that column was an action formulation: No other description is so succinct as to explain the universe on a table napkin—a small one at that.

The action principle is such a powerful tool and so universal in its applicability that Dr. Zee comments, "Some physicists would like to believe that the Ultimate Designer thinks in terms of action."

The principle of least action is very simple to state (and complex to calculate). For any system changing from one state to another, consider each and every way in which the change could happen. For instance, the gravitational change of falling off a wall. For each of these ways, calculate a number—there are no units involved such as miles or seconds—called the 'action' using the formula for gravitational change. The fascinating thing, and no one knows the reason why, (and some scientists have waxed quite metaphysical about it), is that the change that actually happens is always the change that has the smallest number—the lowest action—associated with it (hence the name).

The great challenge of using the Principle of Least Action is, of course, being able to figure out the appropriate formula needed to calculate the action. Some have already been figured out, such as the formula for gravity and the formula for the nuclear force. Others are still unknown. Once you know the correct formulas, however, it becomes possible to deal with complicated situations, because all you have to do is add up the numbers—simple math still has a place in modern physics! For instance, if a change involves both gravity and electromagnetism. First, figure out all the ways the change could happen. For each way, apply the gravity formula to get one number, apply the electromagnetic formula to get another number, and add the two numbers to get the total action. The way of change with the lowest total action will be the one that actually happens. Simple.

It is an aid to humility to remember that, for all its successes, our contemporary science knows the appropriate formulas only for simple cases, but there is every reason to suspect that the same principle holds true for something as complex as childbirth.

A Common Factor

How does this relate to astrology? Is there a factor whose formula appears in both the action for planets and the action for what happens to the child at birth? If so, then we could expect a correlation between the two.

One excellent contender is gravity. Now I know that I just wrote that gravity was out of the question, but up there I was talking about the *force* of gravity, now I'm talking about the *principle* of gravitation, a formula describing gravity. While the force is something between two individual objects, the principle is a mathematical construct that appears in the equations for calculating action.

It is obvious that the gravitational formula appears in the action formulation of planetary motion. But does the principle of gravity appear in the action for childbirth?

I think it probably does for the following reasons. There are clear rhythms, sort of built in clocks, in all living things. Naturally enough, we humans have them as well, including daily, monthly and yearly rhythms. Now to be of use, these internal clocks have to be 'in sync' with the rest of the world (as any frequent flyer will testify to their clocks getting jet-lagged out of sync.). Whatever the total action is that governs these clocks, we can expect that one of the components will be the gravitational formula, as it is this formula which governs the external rhythms with which the clocks have to sync with.

In the womb we are relatively isolated from the rest of the universe, the womb being the total universe to the developing child. At birth, however, our rhythms have to sync up with the rest of the world—a situation that could be considered similar to nine months jet lag. This adjustment process of the internal clocks has an associated action that also includes the gravitational formula.

Now we have the two separate phenomena of planets and one of the happenings of child birth both involving the gravitational formula in some way so it would be no surprise if there was a correlation as witnessed by the astrologers.

Please understand, however, that I'm not saying that this is the way it is, but that it is a plausible, scientific explanation of the phenomenon observed by the astrologers that has implications that can be tested—something scientists insist on.

So there you have it. As I said at the start, from a certain perspective both religion and science have much the same to say about astrology: The phenomenon might well be real but the astrologers have their explanations all wrong. So, Ron and Nancy, I can only hope that these speculations help soothe the sting of criticism: Perhaps you are not as far off the mark as your tormentors would have us believe.

49. INSPIRATION

There was a charming, pink-cheeked academic on a PBS documentary the other day telling us all about Srinivasa Ramanujan, a brilliant Hindu mathematician of the 1920s whose contribution is only now being appreciated. This Hindu whiz didn't fit at all well into the normal concept of a mathematician, one of his peculiarities, the narrator explained a little embarrassedly, was that this genius told his coworkers that a goddess regularly gave him those revolutionary insights that have substantially contributed to 20th century math. The thoroughly Western commentator took pains to explain this oddity away, revealing that he often got his insights

while shaving—he'd mull over a problem for days and suddenly the solution came as the whiskers were being stripped from his face.

It was amusing to watch his explanation because it became clear that he had no idea where his insights came from and that the only reason he didn't ascribe them to a goddess was only because he didn't believe in goddesses.

New Ideas

Where do new ideas come from? One very good way, in my experience, comes from having give-and-take (a much revered phrase in Unificationism) with somebody who is vaguely on the same wavelength as you are. The give-and-take can be conversation (the most productive kind) and reading (the most challenging kind.) I say "vaguely" on the same wavelength not in a derogatory sense but to indicate that a wide range of differences can be tolerated—and in fact some difference is essential—in the generation of new ideas and insights. And while I only mention "reading," some might want to broaden the definition to include movies and other mediums of expression—and as a fan of PBS nature documentaries, I can agree. But at least for scientific insights—the kind I enjoy—the written word is paramount.

Reading a book is like having someone explain their concepts to you without giving you the chance to rebut or question anything they say. You can't get them to stop and explain things more clearly—you can either have them repeat the same thing over and over again by rereading the difficult section or you must pass on without ever getting it. This is why I consider reading to be the most challenging generator of new ideas.

Conversational give-and-take is more flexible which is why it can be the most productive. You can generate new ideas by having to explain something you think you clearly understand but get lost along the way, a great stimulus to clarifying your own understanding. Another generator of ideas is having to defend your concept because the other has got it all wrong from some unreliable source they are convinced is correct. The problem here, of course, is the opposite of the book, you rarely get a chance to completely express your thoughts because the other guy keeps butting in with digressions.

I've mentioned reading, but writing is also generator of ideas. Here the people to whom you are "speaking" to through the book have no chance to respond (at least not until the book is finished) so you have no idea if you're getting your point across.

It is this last situation that is the most interesting to me because I think it is one of the few ways open for the scientific person—usually of little religious intensity—to discover a humility to the realms of the spirit.

The experience of the Hindu mathematician is a common one. You are juggling all sorts of concepts around (perhaps writing a book) trying to make sense of it all when, suddenly, the solution pops into your mind. This is difficult to fit into the concept of the necessity of give-and-take for the generation of new ideas. There is nobody there. If you are aware of the existence of spirit world, however, that "no body" is no problem. If some sort of give-and-take is necessary for new ideas to emerge then we can only assume that give-and-take is happening with no-body but some-spirit (not necessarily a goddess though). Someone there in the invisible spirit world is vaguely on the same wavelength as you and you're sparking ideas together.

You've got to be on the same wavelength, however, or there's no place for ideas to stick. It would be of no meaning for a 10th century peasant ploughing a field to have the idea "ee equals em cee squared" would it. He might think, "What a strange thought" but would probably have forgotten it in moments. When Einstein got that thought, however, there was somewhere for it to stick.

As any creative person can testify, there come those periods when you stare at a blank page (computer screen, canvas, typewriter etc.) and, no matter how you squeeze that gray matter, there is not a glimmer of an original idea to be seen. Then, at other times, for no outwardly discernible reason the ideas flow so thick and fast you can hardly keep up with them, it's almost as if someone were dictating (singing, explaining) everything and all you have to do is get it down.

When the well is dry there seems little you can do to make the waters flow. The best you can do is pray and have a little give-and-take with God. He might not be so interested in your pet project but at least He'll always listen.