6. Science and Religion

Science and religion share the characteristic that neither is a single, monolithic organization. Both are represented by separate groups that share only a few basic features. Science is represented by various branches, such as physics, chemistry, and so on, that all share only the fundamental characteristics that everything they know must be obtained by the scientific method, be verifiable (which is essentially part of the scientific method), and be explainable by natural laws alone. Alan Guth, who was a key sleuth in the development of the inflation theory of cosmology, said that science is "an ongoing detective story". Beyond those three fundamental characteristics, each branch addresses different aspects of the laws of nature and have their own specific methods and materials. Religion is represented by separate sects, such as Hinduism, Judaism, Christianity, and so on, which share the fundamental characteristics that the Universe was created and is controlled by a supernatural being and that nothing need be independently verifiable but must be accepted on faith alone. That the Creator continues to influence the unfolding of the Universe has probably been basic to the belief in a supernatural Creator ever since we humans first conceived of one. Beyond these common beliefs, each sect has its own collection of traditions and practices. Thus, science and religion differ fundamentally; they have the Universe in common but look at it differently. Thoreau wrote: "Science never saw a ghost, nor does it look for any, but it sees everywhere the traces, and it is itself the agent, of a Universal Intelligence."

Introduction to Science

The first principle of science is that knowledge is dynamic; no knowledge is so complete that it can't be improved upon. This is the secret to the incredible expansion of scientific knowledge. After all, being certain that you already know all truth is a barrier to learning. The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom. In her editorial in the 12 July 2013 issue of *Science*, the magazine/journal published by the American Association for the Advancement of Science, Editor-in-Chief Marcia McNutt wrote, "Years ago when a decadeslong debate raged in the geoscience community about whether the seismic discontinuity at 670 kilometers formed a barrier to convection in Earth's mantle, a former mentor asserted that he was one of the few participants in the conversation who was intellectually honest because he had changed his mind as new observations had come to light. He postulated that some of his colleagues were practicing religion, not science." They were practicing religion because they refused to accept that new observations improved knowledge, which therefore, necessitated a change in understanding. The point is simply that failure to change one's view in light of new knowledge is called practicing religion.

Everything science knows is subject to improvement, and the description of how things move through space is an example. In *Philosophiæ Naturalis Principia Mathematica*, published in 1687, Newton codified how bodies move with his "laws of motion," the first of which says, in part, that objects in motion remain in motion with uniform velocity unless acted on by an external force. These laws of motion have been generally successful in describing the movement of many, many objects, such as the orbits of the planets around the Sun. Unfortunately, they fail to accurately describe the orbit of Mercury, and this failure was a very large problem for astrophysics. Einstein slightly modified Newton's laws of motion when he published his Theory of General Relativity, which improved Newton's view of gravity and does accurately describe Mercury's orbit; Mercury is so close to the Sun (in relativistic terminology, so deep in the Sun's gravity well) that it experiences relativistic effects. The scientific principle that knowledge is dynamic directly contrasts with religion; all religions claim to possess revealed knowledge that's absolute, unchangeable. Unfortunately, each sect possesses revealed knowledge that's different from the others.

The second principle of science is that the natural laws that govern the unfolding of the Universe are unchanging either with time or space. The laws that describe how processes work on Earth in the twenty-first century are the same laws that describe how these same processes work in a galaxy 12 billion light years away and in our galaxy when it was formed 12 billion years ago. It's the mission of science to discover and understand these laws.

The first question we face is probably, "What is science?" As Dr. Miller, who testified as an expert science witness in the legal dispute Kitzmiller v. Dover Area School District, said,

> "The word 'science' comes from the Latin word *scientias*, which means knowledge. And in the most general sense, the word 'science' is sometimes used to just say learning systematic knowledge, for example, library science or political science."

But the word "science" when used by itself without qualifying words like "library" or "political" is generally understood to mean a specific type of knowledge: Science is the practice of discovering and investigating, using a specific procedure called the scientific method, the structure and natural processes of the Universe. Of course, living things are part of the Universe, so science includes the discovery and investigation of the structure and natural processes of living things as well as of rocks and galaxies. Nearly all of us, including many, but not all, scientists in their roles as people rather than as scientists (Dr. Miller testified that he is a practicing Catholic), agree that the Universe was created by God in a "Big Bang." Although science can not address the issue of such a supernatural creation itself, it does study what was created. It discovers and investigates the direct work, or word, of God.

By definition, science is concerned with only natural processes (causes), and in a 1986 article that appeared in *Christian Scholars Review*, this bedrock of science was given the name "methodological naturalism" by Paul de Vries, then of Wheaton College. Of course, giving things names is important to philosophers like de Vries but is meaningless to the practice itself since scientists have been concerned only with natural causes since around 600 BCE (before current era) when Thales of Miletus first denied supernatural causes for natural phenomena. Scientists have studied natural causes quite well without it being called anything. The physicist Dr. Richard Feynman (who shared the 1965 Nobel Prize in Physics with Sin-Itiro Tomonaga and Julian Schwinger for the development of quantum electrodynamics) is alleged to have privately said, "Philosophy of science is about as useful to scientists as ornithology is to birds." Birds can carry on the bird trade quite well regardless of what ornithologists say about them, and scientists carry on their work quite well whether or not it's called methodological naturalism or any other name philosophers choose to give it. Birds and scientists do the work while ornithologists and philosophers simply talk about it.

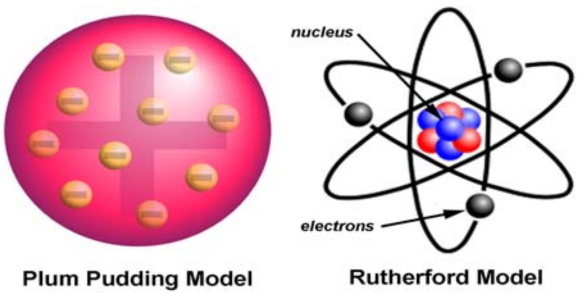
The scientific method is critical to the practice of science because it's the best way yet discovered for separating truth from lies and fact from opinion. The method ensures that scientific discovery and investigations are not the secrets of a select few but can be freely reproduced by anyone at any time. By bringing forth reproducible facts, the scientific method ends the otherwise interminable debates spawned by contrasting, unverifiable opinions. Unfortunately, the method doesn't ensure the end to debate because otherwise intelligent human beings who aren't scientists are sometimes irrational enough to reject reproducible facts that don't agree with their opinions, especially about religious matters. Intelligent design and young Earth advocate Phillip Johnson, a University of California law professor, has said, "I say after we have settled the issue of a creator, we'll have a wonderful time arguing about the age of the earth." He's ready to ignore many, many reproducible investigations that reveal Earth to be 4.8 billion years old in favor of a religious opinion that it's only a few thousand years old. Of course, he's a lawyer and not a scientist, so his training has probably predisposed him to prefer opinion to fact. They aren't called "legal opinions" for nothing.

Although the scientific method has no rigid set of steps, it always includes three vital phases: hypothesis, testing, and publication. An hypothesis is a tentative description of the structure or natural process being investigated, and it could be right, partially right, or completely wrong. As an example of a typical scientific hypothesis, British physicist and Nobel laureate J.J. Thomson proposed in 1904 that the atom's structure was like a pudding of positive charge with negatively charged electrons imbedded in it like raisins in a pudding. An hypothesis could arise in response to a question, an observation, or a mathematical development of related phenomena. In any case, the hypothesis usually covers a single fundamental principle. Science has built a giant edifice of knowledge, brick by brick, of such fundamental principles.

Limiting the scope of the hypothesis to a single fundamental principle allows testing it to be manageable, and tests are vital to either falsify or verify (but not prove) the hypothesis. A statement can never be claimed to be true unless it can be verified. Without falsifiability (or conversely, verifiability; falsifiability and verifiability are simply two sides of the same coin) by tests, there is no science. To be science, an issue must be able to be shown to be either supported or falsified by tests. For example, even the proponents of String Theory readily admit that, in spite of its rigorous mathematical development, its significant shortcoming is that no test has yet been devised to verify it. Designing and executing a test is often a very difficult process that generally involves using the hypothesis to predict what should happen under specific conditions that could be created in a laboratory. If the experimenters see the predicted result, the hypothesis is scientifically considered to be supported, but not proved, and essentially then becomes a theory. If the experimenters don't see the predicted result, the hypothesis is considered false and must be either abandoned or modified and retested. An hypothesis can only be proven false (falsifiable); it can never be proven true, merely supported, or verified, by that particular test. The hypothesis remains a valid theory as long as it passes each test, and the more tests done that support the theory, the stronger the theory. In keeping with the first principle of science, scientists are able to accept all knowledge as provisional.

In 1909, Hans Geiger and Ernest Marsden, under the direction of Ernest Rutherford, tested J.J. Thomson's hypothesized plum pudding model of atomic structure by the gold foil experiment. They shot a beam of alpha particles, which are composed of two protons (which have a positive electric charge) and two neutrons (which have no charge), at a gold foil. The plum pudding model of atomic structure predicted that the positive charge of the atom's nucleus would deflect the positively charged alpha particles (like charges repel) by various amounts depending on how close to the spread out, positively charged "nuclear pudding" the alpha particle came, and the deflection was expected to be only a few degrees at most. However, Geiger and Marsden saw an extremely high percentage of alpha particles passed through the foil without being deflected at all, as if they encountered no positive charge whatsoever in the gold foil. But a few particles were deflected at large angles, occasionally almost straight back to the source. Rutherford was very surprised by the result and said it was like shooting a 16 inch shell at tissue paper and seeing it bounce back at you. The tests proved that the atom is mostly empty space, and its positive charge is concentrated in a very small region. The plum pudding hypothesis was therefore wrong.

In the final step of the scientific method, testers must publish their findings so the scientific community can verify that the experiments were



Early Models of the Atom

The Geiger-Marsden experiments directed by Rutherford supported a model of the atom in which most of its mass is located in a small nucleus rather than spread out like a plum pudding. The actual distance from the nucleus at which the electrons orbit is much, much farther than shown here. The distance is so great that it's impossible to draw an atom to scale.

properly designed and executed and the conclusion drawn from the results is valid. The beauty of science is that other scientists can learn from published findings and perform their own experiments to further verify or expand upon them. Occasionally these other scientists can not verify original findings, leading to an intensive, and sometimes scathing, review of the original work that may reveal inferior test procedures or even, rarely, fraud. Science is not for the faint of heart. Geiger and Marsden published a description of their gold foil experiment to test Thomson's plum pudding model of the atom in a 1909 issue of the *Proceedings of the Royal Society*. Two years later, Rutherford published the experimental results along with a revised model of the atom in the *Philosophical Magazine*. The fundamental principle of atomic structure was established: that the atom is mostly empty space with a small, positively charged nucleus around which electrons orbit at very, very large distances relative to the size of the nucleus. Other research in the years after Rutherford's paper have continued to verify this description of atomic structure and refine our knowledge of it.

Because it encompasses the entire Universe, science is an extremely broad field of study. In the millennia since Thales of Miletus denied that natural phenomena had supernatural causes, science's knowledge base has grown so large that no one can know it all. There is no Aristotle any more. Science has many, many fields of study such as physics, chemistry, and so on, so any statement that begins with "Science says…" is meaningless. There is no monolithic "Science." Each field of study is further roughly divided into two specialties: theorists, such as J.J. Thompson and Ernest Rutherford, and experimenters, such as Hans Geiger and Ernest Marsden. Occasionally, theories are so mathematically complex (String Theory comes to mind) that theoretical physicists partner with mathematicians.

Not all hypotheses are scientific. For example, the hypothesis that blue is a better color than red is not a scientific hypothesis because it's merely an opinion that can't be tested. On the other hand, the hypothesis that more people prefer blue than red is testable and therefore is a scientific statement. The human preference for one color over another would be an example of what is sometimes colloquially called "soft science" as opposed to "hard science." *Mosby's Dictionary of Complementary and Alternative Medicine* defines soft sciences as a "slang term for the body of research that often uses more subjective and difficult-to-control measures and designs, such as psychology and the social sciences." Soft sciences, which include psychology, sociology, anthropology, and political science, interpret human behavior, institutions, and society and depend more, but not exclusively, on qualitative rather than quantitative analysis of data. The term "soft science" is sometimes inferred to be pejorative, but no pejorative use is implied here.

Hard science is usually equated to what is commonly called "natural science." The most fundamental natural science is physics (including astronomy) because it's the only one that describes phenomena occurring in the Universe throughout all space and time from the instant of the Big Bang (time equals zero) to the present time. It's the study of the nature and properties of matter and energy and encompasses heat, light and other radiation, sound, electricity, magnetism, the structure of atoms, and mechanics, which includes both statics (the study of forces on stationary objects such as buildings and bridges) and dynamics (the study of objects in motion). Physics doesn't draw on discoveries and investigations of any other branch of science. Ernest Rutherford, who won the Nobel Prize for his discovery of the atom's basic structure as described earlier, once made the rather harsh observation, "Physics is the only real science. The rest are just stamp collecting." The irony is that he won his Nobel Prize in chemistry.

One of the characteristics of physics and chemistry that make them hard science is that every principle, from microscopic Quantum Electrodynamics to macroscopic formation of a star, is mathematically describable. Additionally, their mathematics for macroscopic phenomena uses specific numbers rather than statistical quantities such as are often employed in the soft sciences. For example, Newton's mathematical description, or equation, of the gravitational, attractive force, F, between two bodies of masses m_1 and m_2 separated by distance r is

$$F = G\,\frac{m_1\ m_2}{r^2}$$

where G is simply a constant (a number) the value of which depends only on our choice of measurement units (e.g., distance in meters or miles). In English, this equation says that the force on each mass is equal to the constant G times the product of the two masses divided by the distance between them multiplied by itself. The masses m_1 and m_2 are numbers that represent the amount of "stuff" in each body. The masses, m_1 and m_2, and the distance between them, r, will be different from situation to situation, but the constant, G, is the same everywhere in the Universe. This equation describes the force between bodies as small as electrons or as large as stars and uses specific numbers for the masses, distance, and constant to calculate a specific number for the force in each situation.

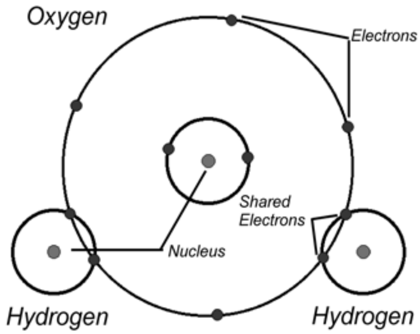
However, as far as we know right now, subatomic phenomena such as the position and velocity of an electron are only describable using probabilities because trying to measure such small things inevitably disturbs them and makes the complete answer unreliable. We can measure either the position or velocity of an electron but not both at the same time. The study of subatomic particles is the field of physics called Quantum Mechanics.

The position and velocity of a subatomic particle such as an electron are describable only by probabilities because subatomic particles are so small. When we see something, a car for example, the object is illuminated (e.g., by the Sun or a police officer's radar gun) to determine its location and velocity, and we detect the reflected light. Subatomic particles are so small that any illumination disturbs them by adding energy to them, making the observation of their position and velocity uncertain. The energy added to large objects like a car is so small relative to the size of the car that it has no discernable influence on the object. Werner Heisenberg's Uncertainty Principle mathematically describes the minimum amount of uncertainty in our knowledge of a particle's position and velocity; we can never know them more precisely than the principle allows. It's a fundamental limitation. We always describe things that are uncertain, such as the position of an electron or the next card in a poker game, with probabilities. Nevertheless, physicists have developed a precise mathematics of Quantum Mechanics such that the probability envelope of an electron in an atom, its shape and size, is well known. We might not know exactly where an electron is in its probability envelope, but the envelope itself is well known. Moreover, we've discovered that the electrons in an atom have specific relationships with one another such that each electron has a different probability envelope. The mathematics of Quantum Mechanics is very complex, but it's enough for the purposes here to know that it exists.

Theories of complex phenomena, like the formation of stars, are assembled by combining many fundamental principles (such as the structure of an atom) in the same way the pointillist Georges Seurat combined small dots of primary colors to paint *A Sunday Afternoon on the Island of La Grande Jatte 1884*. Both combine a plethora of small things in such a way as to create a well-structured whole. These theories might be called grand theories because they are complex combinations of many fundamental principles. It's this complexity, not the scale of the phenomena addressed, that makes them grand theories. There are grand theories of microscopic things such as how the atomic nucleus is held together as well as of large things such as how stars form. Each fundamental principle included in a particular grand theory has to be acquired by the scientific method. For example, the fundamental principles used to construct the grand theory of star formation include the gravitational attraction between particles (in the equation above), the energy of motion (kinetic energy) of particles, the attraction and repulsion of electrically charged particles, the conversion of matter into energy ($E = mc^2$), the transfer of heat by both conduction and radiation, and many others, each of which has been verified by numerous independent laboratory experiments.

Chemistry Studies Atoms and the Bonds they Form to Make Molecules

This is the classical illustration of the bonds that hydrogen and oxygen form to make water. This type of bond is called a covalent bond. It's formed by hydrogen and oxygen sharing electrons. Current preferred diagrams differ from this classical illustration to be consistent with modern atomic theory.



Obviously, grand theories of large-scale phenomena like the formation of stars can't themselves be tested in a laboratory; instead, nature is the laboratory. In star formation, for example, scientists measure a star's mass, luminosity, and so on to verify that they match values predicted by the mathematics of the grand theory. Grand theories are sometimes synthesized to explain measurements of observed phenomena and are, therefore, often assembled in reverse: data first, theory second. The theory of supernovas is an example; observational astronomers first noticed the phenomenon and collected data on the explosions before astrophysicists assembled a theory from the data. After a grand theory is synthesized, advances in technology inevitably create opportunities for more precise measurements or different types of measurements in nature's laboratory to verify or falsify the theory. But grand theories are so complex that disagreement between subsequent measurements and mathematical calculations doesn't automatically invalidate the theory. Instead it might simply imply that there are additional fundamental principles that must be included in the theory, or that the fundamental principles were incorrectly applied. So disagreement between measurements and calculations of a grand theory merely means that the theory must be modified rather than discarded. Discarding a grand theory like the theory of evolution rather than modifying it when a glitch appears is like burning your house down to fix a termite problem.

Chemistry is another fundamental science because it draws on only the principles of physics (such as mass, energy, and so forth) to explain the phenomena it studies. Chemistry is essentially the study of the ways that electrons in atoms react with those in other atoms to form more complex substances, called molecules. The 92 natural elements can combine in so many ways that chemistry is a vastly complex science. Carbon alone can combine in such a myriad of ways that it has its own enormously complex branch of study called organic chemistry, and the chemistry of life, which is very, very briefly described in the Appendix, is a part of organic chemistry.

Geology, which is the study of the constituent materials and the processes that operate on those materials for every body in the Universe that doesn't undergo nuclear fusion (i.e., for every body that's not a star), might be called a secondary science because it uses fundamental laws of nature

The Grand Canyon

The Grand Canyon has been cut deep into the Colorado Plateau probably by a succession of rivers, the most recent being the Colorado River. The canyon is like a geology textbook, instructing us on millions of years of the plateau's geological past.

that are discovered by physicists and chemists. Obviously, the Earth and, occasionally, the Moon (and remotely, Mars) are the only bodies we can access at the present time, so those are the primary focus of the geological sciences. Geology is an extremely broad science, incorporating the solid, liquid, and gaseous portions of the planet, so volcanology, oceanography, Earth science, and atmospheric science are among the specialities under the geology umbrella. For example, the American Geophysical Union (AGU) publishes the *Journal of Geophysical Research* (JGR) with parts (independent publications) on Atmospheres, Biogeosciences, Earth Surface, Oceans, Planets, and Solid Earth. The AGU Web site says, "The American Geophysical Union (AGU) is an international nonprofit scientific association with over 50,000 members. Established in 1919 as a committee within the National Research Council of the National Academy of Sciences, AGU was independently incorporated in 1972. Since its founding, AGU is [sic] dedicated to furthering the sciences of geophysics through the individual efforts of our members and in cooperation with other national and international scientific organizations."

Because geology's focus is on grand theories of large-scale phenomena such as plate tectonics, geologists do little or no research on fundamental principles, generally drawing instead on fundamental principles from physics and chemistry to synthesize grand theories that describe natural phenomena such as plate tectonics, volcanoes, and tropical cyclones. Geologists analyze copious measurements of everything from water temperatures to rock densities that enable them to understand the status of the Earth for many, many diverse factors, from heat stored in the oceans (a factor in global warming) to where to look for oil or mine for ores.

One relatively small, though significant, task of geology is measuring the age of the Earth. Geologists usually do this by using the known decay rates of various radioactive elements, such as Potassium 40 (K-40), which decays to Argon 40 (Ar-40); Rubidium 87 (Rb-87) to Strontium 87 (Sr-87); Uranium 235 (U-235) to Lead 207 (Pb-207); and Uranium 238 (U-238) to Lead 206 (Pb-206) all of which are listed in the Half Life Table on page 30, that are contained in the various minerals that make up rocks. Ernest Rutherford was the first to use radiometric dating when he determined the age of a piece of uranium ore in 1905. This fundamental principle and advances in instruments made it possible by the 1940s to determine dates that are accurate enough for geologists to use when calculating the age of igneous rocks, which are rocks that form directly from cooled magma. As described in Chapter 2, Rock ages are calculated by measuring the amount of radioactive material (e.g., U-235) and decay product (e.g., Pb-207) and working backward using the decay equation to calculate the age of the sample. The amount of decay product is calculated by subtracting the initial quantity from the measured quantity. Determining the initial quantity is a major source of measurement error in the process when it's used on most minerals in rocks. Of course, the process is a bit more complicated that the thumbnail sketch provided here.

Chapter 2 also mentions that accuracy of radiometric dating improved dramatically when zircon was discovered to reject lead but accept uranium in its crystal structure, so the major source of error (the uncertainty in the initial amount of decay product) is now almost completely eliminated when zircon is used for both of the uranium-to-lead decay series (U-235 to Pb-207 and U-238 to Pb-206). Moreover, because both U-235 and U-238 are usually in the same zircon crystal, the analyst has an inherent cross check by comparing the dates from both decay series. Dr. Paul Mueller of the University of Florida says, "Depending on the history of the rock, we can date things nowadays down to something on the order of a few hundredths of a percent of its age."

Biology is a natural science that draws on fundamental principles from physics and chemistry to investigate life and living organisms. Biology requires the presence of life; in other words, if there's no life in the Universe, there's no biology (or science of any sort). In that sense, it's a conditional natural science. In addition to using fundamental principles from physics and chemistry, biologists discover fundamental biological principles in such fields as microbiology, biochemistry, and cell and developmental biology. For a long time, biology was limited to the study of anatomy and the function of an organism's various systems such as muscular or vascular. Beginning in the late nineteenth century, knowledge in the biological sciences began to expand rapidly like it did in the physical sciences.

A knowledge explosion in biology began in earnest when Watson and Crick discovered the structure of DNA in 1953. They didn't discover DNA; they discovered its structure. Scientists had been aware of DNA's existence since the Swiss physician Friedrich Miescher discovered a microscopic substance in the nuclei of cells in 1869; he called it "nuclein." By 1920, the nuclein (DNA) molecule was thought to be a chemical base unit attached to a chemical structure called a nucleotide; base and nucleotide combinations were then connected in a chain by another chemical structure that had phosphorous as an important part (see the Appendix). So in 1953 scientists knew everything but what it looked like, or its structure, which was called the "holy grail" of biochemistry. "Holy grail" is perhaps a bit of an exaggeration, but everyone knew that a Nobel Prize awaited anyone who could discover the structure because DNA couldn't be studied until its structure was known. Recall that discovering the structure of the Universe and its parts is one of the fundamental goals of science.

Since 1953, investigations of how DNA works have been a major scientific odyssey and have significantly contributed to what is undoubtedly the greatest grand theory of biology: the Theory of Evolution. When Darwin proposed the theory, he didn't know the mechanism that made it work because knowledge of biology was too primitive. The discovery of DNA, its structure, and how it works has revealed that mechanism to us. Moreover, as mentioned in Chapter 4, genes have been discovered to have measurable mutation rates that provide us with a "molecular clock" that can be used to identify the time when two evolutionary lines diverged from their last common ancestor, when our genus, *Homo*, diverged from chimpanzees, for example (around 4 million years ago).

A point made earlier is worth repeating here: there's a difference between evolution and the Theory of Evolution. Evolution is the natural process of God's laws of nature operating on biological systems, whereas the Theory of Evolution is the description, or Grand Theory, of how we currently best, though imperfectly, understand that natural process. Evolution is an opportunistic process grounded in random mutations in DNA. The fundamental principles that drive the natural process of evolution are often as simple as the fundamental principle of survival (and, by extension, of evolution): to eat but not be eaten. The enormous complexity of evolution, and our understanding of it, derives from the myriad of ways in which life addresses this fundamental principle of survival and the resulting interconnectedness of all life. Understanding that complexity is an enormous task, and we'll probably never completely understand it. The Theory of Evolution will never perfectly describe the natural process of evolution; we are, after all, only human, not God. But it will constantly get better and better.

Since it was first proposed in the nineteenth century, the idea that evolution exists as a natural process has been adamantly opposed by the religious community because it conflicts with their view that around 5000 years ago the Deity created all life as it currently exists. In the time since the first objections were raised in the middle of the nineteenth century, the opponents of evolution as a natural process have continually, but slowly, backtracked to the point that some now admit evolution occurs, but only among microbes (microevolution), whose evolution by natural selection is undeniable because of the many, many instances of bacteria developing a resistance to antibiotics. However, intransigent opponents still deny that large species can evolve.

Just as the weight of evidence eventually overcame religious intolerance of Galileo's heliocentric universe, it will eventually overcome religious intolerance of evolution as a natural process. We are an evolved species that has appeared very recently in terms of Earth's history. Our success is a product of our magnificent brain, which has enabled us to be the first species to lift our eyes from the dirt beneath our feet to gaze upon the far reaches of the Universe and the first to wonder where we came from. Just as our great brain has enabled us to overcome seventeenth century religious objections to Galileo's observation that the Earth is not the center of the Universe, so it will eventually allow us to understand that evolution is one of the abiding principles of God's Universe. The Deity created the Universe to function this way, and that's how it is. To deny evolution is to deny God. Unfortunately, there's a wide gap between scientists and the general population in understanding how the Universe works.

Those who refer to the Theory of Evolution as "just a theory" display an abysmal lack of understanding of what a scientific theory is. This lack of understanding is probably fueled by the cavalier use on the term "theory" by the general public. In common usage, the term "theory" seldom implies the level of support that a well-tested scientific theory has; it's more akin to a speculation, which scientists call an hypothesis. For example, a police officer might claim to have a theory on who committed a crime. which may then guides the officer in collecting evidence in the same way an hypothesis guides a scientist on what tests to perform. In this example of common use, "theory" is more like speculation and comes before support as measured by evidence, which may exonerate the suspect or be admissible in court and support an arrest warrant. This is the same procedure as the scientific method in which hypothesis comes before tests that can either falsify or support the hypothesis, which support leads to upgrading the hypothesis to the status of a theory. Thus, a police officer's "theory" is not like a scientist's theory, but more like a scientist's hypothesis.

Science continues to expand the frontiers of knowledge by discovering new structure and new principles by which God's Universe operates. The two areas where the expansion of knowledge is perhaps the most interesting right now are astrophysics and microbiology.

Along the frontier of astrophysics knowledge are the new discoveries of dark matter and dark energy. Our knowledge of both is little more than the simple understanding that they exist, but further expansion of our knowledge of them might open a new physics as advanced beyond what we now know as Einstein is beyond Newton or perhaps even Thales of Miletus. We cannot know where understanding dark matter and dark energy will lead. They might lead us to compact sources of energy or a propulsion system that will enable us to travel to planets in other star systems.

We have a much better understanding of where advances in microbiology will lead. Microbiology research currently has two main thrusts: understanding how the brain works and using DNA both as a weapon against harmful agents such as insects and bacteria and as a way to transform certain bacteria into beneficial agents.

For example, gene therapy expert at the University of Pennsylvania Dr. Carl June has discovered a therapy for the treatment of chronic lymphocytic leukemia (CLL), which is a blood cancer characterized by uncontrolled accumulation of malfunctioning B cells in the blood, bone marrow, lymph nodes, and organs such as the spleen and liver. B cells make antibodies (large proteins) used by the immune system to identify and neutralize antigens, which are objects, usually foreign such as bacteria and viruses, that cause the B cells to produce antibodies against them Thus, B cells are an essential part of the immune system (unless they malfunction). Cells in living things have evolved a system for self correcting; when cells become useless due to old age or damage, an internal signal is given, and the cell commits suicide, one method of which is called apoptosis. In CLL, useless B cells don't commit suicide, so they continuously accumulate, gumming up the works, so to speak. The failure of apoptosis is a feature of all cancers. At present, here is no known cure for CLL, and life expectancy is around 7 years. However, Dr. June has been able to reprogram the DNA of another immune system cell, the T cell, to hunt and kill useless B cells.

It is important to reiterate that the most important feature of science is verifiability.

Introduction to Religion

The first five chapters of this work is an extremely brief science-based sketch of the Universe's evolution from the Big Bang to present times. This covers roughly the same events that are described in Chapter 1 of the *Bible*'s (and the *Torah*'s) *Book of Genesis*, which tradition says was authored by Moses sometime around the year 1450 BCE, the exact date unknown. (However, modern Biblical scholarship no longer attributes the *Book of Genesis* to Moses.) We now leave the relatively clear waters of science, where everyone may not always agree but at least treats other opinions with civilized respect (although Donald Prothero on page 130 of *The Eocene-Oligocene Transition: Paradise Lost* says that "Scientific meetings can degenerate into shouting matches and name calling, although the preferred method of attack is to demolish one's opponent with a witty riposte."). Our journey continues into the murky waters of religion, where respect for other's opinions is a hit or miss thing and where believers hold their faith tightly, entertain no compromise, and often defend their faith with unrestrained violence.

If one accepts the premise that God created the Universe and its laws of nature, then science and religion both pursue the same thing: to know and understand the word of God because the laws of nature are the word of God. The primary differences between the two is their respective methodology and criteria for determining truth. Of course, science can't examine a supernatural event such as divine creation because it's neither reproducible nor verifiable (or falsifiable) and, therefore, not within science's purview.

Many individual scientists such as Dr. Miller, who, as mentioned earlier, testified as an expert science witness in the legal dispute Kitzmiller v. Dover Area School District, are religious people. Dr. Miller is Catholic and finds no conflict between his religious beliefs and his practice of science. Dr. Miller is in good company. The Augustinian friar Gregor Mendel performed fundamental scientific experiments from which he deduced the laws of heredity. The Belgian priest Monseigneur Georges Lemaitre noticed two years before Edwin Hubble published his data that the equations of General Relativity imply that the Universe is expanding, although Einstein at first rejected the notion. Lemaitre was also the first to propose the explosive beginning of the Universe, which he called the "hypothesis of the primeval atom". An explosive beginning is a natural corollary of an expanding Universe.

All religions have evolved from their early roots over the years as new generations of church leaders seek to put their stamp on the ways of humankind by interpreting and expanding upon the earliest holy books. For example, the hierarchy of the Roman Catholic Church interpreted Chapter 1 of the Bible's *Book of Genesis* to say that Earth is the center of the Universe consistent with Ptolemy's model described in Chapter 1, although Genesis is actually silent on the specific structure of the Universe. After all, when Genesis was written, the Earth was all that was known of a "Universe". However, when Galileo favored the heliocentric model of Copernicus, he ran afoul of this interpretation. The Catholic Church tried to simply silence Galileo, but that bell could not be unrung.

Most people think of religion as a belief in a divine or superhuman power or powers to be obeyed and worshiped as the creator(s) and ruler(s) of the universe, and that's the way we'll look at it here. Of course, other people choose a broader definition; there is no universally accepted definition. The definition used here sets Buddhism aside because Buddhists don't directly address the issue of a Supreme Being or Creator. Buddhism is a system of beliefs and practices that enable the practitioners to cope with the world we have, which they see as being filled with suffering. As the Theravada Monk Bhikku Bodhi wrote, "The four truths all revolve around the recognition of suffering (duhkha) as the central problem of human existence, and in the first truth the Buddha enumerates its diverse forms: 'What is the noble truth of suffering? Birth is suffering; decay is suffering; death is suffering; sorrow, lamentation, pain, grief, and despair are suffering; not to get what one wants is suffering; in short, the five aggregates of clinging are suffering.'"

Most people are reasonably familiar with their own creed, though obviously not as familiar as a religious official is. What's more, Dr. Mark W. Muesse, a Professor at Rhodes College, a small Presbyterian college in Memphis, has said, "Most religious people throughout the world, even today, consider ritual much more important than doctrine and belief." Thus, few people are familiar enough with the fundamental doctrine of any religion, even their own, or of religion as a cultural institution to have a broad view. That broad view of religion is what the rest of this chapter is about.

It's important to understand at the outset that there's no universal story here; each story is as individual as its people. There are only vague, general similarities. It's also important to understand the difference between God and religion: God is the creator of the Universe, whereas religion is a viewpoint shared by a specific culture or subculture on the best way to "find", "understand", and worship God. There are as many religions, from Aladura of eastern Africa to Zoroastrianism of India, as there are cultures or subcultures, and each religion meets the needs of its own group. Some, such as Christianity and Islam, claim to be the only true religion whereas others, such as Hinduism, for example, admit to be but one of a number of acceptable ways to find God.

Religion is a construct of humans (though all religions dispute that) seeking to understand our relationship with the Creator. Once we became aware of the existence of supernatural beings, we began to try to understand how we related to them. Religion is a human construct because the Deity has never given any instruction to us; there's never been an instance when people conversed with God or God's agents, which are called angels, though many people have made unverifiable claimes to have done so. These claims of conversations with spiritual beings are called revelations. No revelations have ever been verified, so we're left with simply believing or not that these people speak the truth. The belief that God converses with us is one of the abiding characteristics of religion. Of course, by rejecting revelations as true, this chapter can be considered by some as biased, although it could also be considered biased if revelation were accepted as true. There's no middle ground here, so this chapter stays with the principle that verifiability is necessary for truth.

We begin before history. On page 12 of Volume I, *Our Oriental Heritage*, of his eleven volume work, *The Story of Civilization*, the historian Will Durant said of history, "...(for most history is guessing, and the rest is prejudice)...". History is the recorded activities of people. Events that happened before the earliest records are prehistory, and we can only guess at them. However, our guesses of the time before history can be educated by historical times if we assume that people have always been fundamentally the same.

Eons ago, before there words written or people who could read them, religion began when some of our ancestors made a quantum leap of imagination; they managed to conceive of something that was totally outside the realm of their experience. For a few million years, they had struggled to survive in a world filled with danger. They'd slowly learned survival skills like tool making and fire handling by observing their environment and applying what they saw, which is something of a scientific process. But one or more folks somewhere, sometime in our past conceived of something that wasn't part of the environment. It couldn't be seen, heard, smelled, tasted, or felt; it was a spirit, and religion was born.

No one knows when our ancient ancestors first conceived of spirits or whether it happened at only one place and time and spread from there or

Shanidar Cave

Although interpretations of the find are disputed, Shanidar cave is the site of what is perhaps the first known ritual burial, suggesting a belief in some sort of spiritual afterlife. On the other hand, the conditions surrounding the deceased found here could simply be expressions of fondness for the individuals. Assigning a specific intent to prehistoric actions is speculative.

happened at several places and times. We do know that almost everyone all over the world believed in the existence of a spirit world by the time history began to be recorded.

One of the earliest known archeological sites that seem to have a spiritual overtone was discovered around 1959 by Columbia University's Ralph Solecki in northern Iraq's Shanidar cave. The cave is in the hills along a tributary of the Tigris River called the Great Zab and is like a great, yawning mouth perhaps a hundred feet wide and four stories high in the side of a hill. Remains of Neanderthals from around 50,000 years ago were found in what has been interpreted as a burial site. The remains of the individual called Shanidar 2 were found under a pile of stones that contained some worked stone points that some have interpreted as grave goods, indicating that some sort of primitive ritual might have been involved. The individual known as Shanidar 4 has also been interpreted to be the beneficiary of ritual burial because he was lying on his left side in a partial fetal position, and soil samples from around the remains contain pollen from numerous flowers that grow in the area as if there was a floral display for the individual. Some archeologists disagree that the flower pollen necessarily implies a ritual burial because a rodent called the Persian Jird that is native to the area stores seeds and flowers in its burrows, suggesting that the pollen might be a modern contaminant.

The assumption that the gods manipulate the Universe is vital to their being conceived in the first place because it was the necessary link between the visible and invisible worlds that made the idea of a spirit world possible, at least at that time. The reasoning was, and remains so today, that if we can't explain how something happened, the spirits must have done it. Spirits could have been first imagined to explain dreams or to explain natural phenomena where no natural cause and effect was evident. The Norse, ignorant of the relationship between lightening and thunder, explained thunder as the god Thor pounding on a divine anvil with his hammer. Egyptians of the Old Kingdom, ignorant of the effect rains in central Africa have on the rise and fall of the Nile, believed the goddess Anuket brought the annual flood.

To assign the cause of a phenomenon that was beyond understanding to the activity of a god was ubiquitous among primitive beliefs, and this relic of ancient belief has remained a fundamental assumption of all religions ever since. We have yet to outgrow that primitive notion. In fact, belief in a God to whom one can pray in the expectation of possible aid has occasionally been used as part of the definition of religion (e.g., in a questionnaire sent several years ago by the American Association for the Advancement of Science).

Even modern scientists such as biochemist Dr. Michael Behe sometimes fall victim to that fallacious reasoning. Dr. Miller, in his testimony during the trial Kitzmiller v. Dover Area School District said, "As far as I can tell, there is no affirmative evidence for a designer in Dr. Behe's book either. Both books rely entirely on negative inferences by saying that, if evolution has problems, if evolution is wrong, if evolution cannot provide complete explanations, then we can go ahead and say it's a designer." Of course, Dr. Behe disagrees with that assessment.

Although the idea of a spirit world was widespread in ancient times, specific gods were not. They tended to be local to a town or small region because routine travel and the spread of a specific culture over long distances was uncommon. Egyptians had their collection of local deities, as did folks in Mesopotamia, India, and the Americas.

The spirit world was most likely sparsely populated in the beginning. But once the idea of a spirit was born, these unseen beings were probably seized upon to explain anything that didn't have any other obvious explanation. Our ancient ancestors rapidly populated the spirit world with a large array of gods that were believed to control fertility, war, rain, sun, harvest, hunting, and all other aspects of life.

Of course, once a god is imagined to control something, the hunt, for example, it's easy to see that it would be advantageous if the spirits would look favorably on our efforts and reward us with success. This 'gimme-gimme' view has been an integral part of how people see our relationship with the Creator ever since history has been recorded and probably has been with us ever since prehistoric times when the spirit world was conceived. Our natural survival instinct, which is the ultimate preoccupation with self, makes it inevitable that we seek any advantage we can, and there's no greater advantage than to have the favor of the gods.

Our hunter-gatherer ancestors probably thought it prudent to have a member of the tribe who appeared to be specially gifted, often a woman, to speak to the gods for them. These individuals were able to achieve a state of religious ecstasy, perhaps through the use of psychotropic herbs or

Paleolithic Cave Painting at Dordogne, France

This cave painting of a half bull and half human, which is dated to approximately 20,000 years ago, is considered by many anthropologists to represent a shaman's spirit. Shamans often identified strongly with an animal, frequently with the bear because of its strength. Bear cults were common among hunter gatherers. Shamans used noise makers to frighten away evil spirits and resorted to magic incantations and ritual dances to contact the Gods and heal the sick. If spirits were actually as powerful as believed, that they can be frightened by mere noise makes no sense. The search for comfort has always led people to abandon reason.

rapturous dances. In 1552 they were given the name, shaman. Shamans used this religious ecstacy in ritual healing and communicating with the gods. Shamans were probably the precursors to the priests of agrarian cultures.

Shamans often chose to identify with a specific animal, usually a powerful one such as a bull or a predator such as a fox, wolf, or bear, and bear cults were relatively common among hunter-gatherers. Shamans believed that they channeled the animal's power in their ecstatic trances. To help channel the animal's power, they sometimes wore its hide in their rituals just as Aztec priests wore the flayed skin of sacrificial victims. Several rites of the ancients have been passed down to historic times.

The 'gimme-gimme' view of our relationship with the Creator is a relic of our primitive religious roots that we still cling to today. Asking the Great Spirit(s) for favors is the primary function of prayer, which usually begins with a section praising the Deity, follows with a section requesting a favor, and ends with another, optional, section praising the Deity again. Most prayers in all religions follow this same format as exemplified by Christianity's "Lord's Prayer" as given in the *Book of Matthew* 6:9-13 (from the King James Version of the Christian Bible):

9 After this manner therefore pray ye: Our Father which art in heaven, Hallowed be thy name.
10 Thy kingdom come, Thy will be done in earth, as it is in heaven.
11 Give us this day our daily bread.
12 And forgive us our debts, as we forgive our debtors.
13 And lead us not into temptation, but deliver us from evil: For thine is the kingdom, and the power, and the glory, for ever. Amen.

We ask the Creator of this unfathomably enormous and complex Universe to be on our side in everything from international politics and war to winning a high school football game. The advantage to be gained should the Creator possibly favor us in our little endeavors on this third rock from an undistinguished G class star in a quite ordinary galaxy of our vast Universe is a possibility too great to ignore.

When thanking the gods for the favors received and encouraging them to give more, our ancestors felt it prudent to share their success with the gods by sacrificing a part of the bounty, so prayer and sacrifice have been a part of religious practice probably since the spirit world was first conceived. The third book of the Pentateuch, *Leviticus*, spells out in great detail the various sacrifices ancient Hebrews were to make to thank the Creator of the Universe and to gain His favor. Naturally, an offering intended to thank and win favor with the gods couldn't be inferior; it had to be one of the best available as *Leviticus* 1:3 says, "If his offering be a burnt sacrifice of the herd, let him offer a male without blemish..."

A sacrifice had to be as perfect as possible, without blemish, because that's what a god deserves. The same was true of the Capacocha, the sacred Inca ceremony of human child sacrifice. It's believed that the sacrificial children had to be perfect, without so much as a blemish or irregularity in their physical beauty. Human sacrifice was wide spread among the Inca and Aztec, and large numbers of defeated enemy were sometimes sacrificed to thank the gods for victory. Apparently, quantity could serve as well as quality. Modern worship has largely backtracked from the ancient sacrifice rituals.

The practice of religious expression during the first eons of its existence is lost to us because people hadn't yet invented writing. But it has become obvious that, by the time writing was invented around 3000 BCE in Samaria and Egypt, the basic assumptions of all religions had been widely adopted, though not yet formally expressed in holy books. These holy books would come later, so all ancient religions were initially passed down orally from generation to generation. Naturally, when writing was invented, these oral traditions, or dogma, were written down. Thus, all religions of literate cultures have a body of holy texts that delineate its beliefs and practices.

The earliest Hindu holy books are the *Vedas*, which are about 3,700 years old, and were handed down orally for over 1,000 years before finally being written down. The holiest Jewish holy book is the *Torah*, which was written over 2,500 years ago. The *Torah* is combined with books by the prophets as well as other writings to form the *Tanakh*. The Christian holy book is the *Bible*, which includes the *Tanakh*, reflecting Christianity's Jewish roots, and a 2,000 year old *New Testament*. The Islamic holy book is the *Qur'an*, which is around 1,400 years old. Although writing had been around for two millennia, the *Qur'an* was initially orally transmitted (*Qur'an* means "the recitation"), and purists still maintain that recitation is the only proper way to study it. There are only general similarities among these holy books; each is a product of its own religious tradition. The most significant similarity is that all are claimed to have been received directly from God and are, therefore, without error.

It's also clear that, by the time the holy books were written, each religion had created an administrative structure of priests that, in some, was quite extensive. The priests led the believers in rituals of worship and explained the holy writings. The complexity and elegance of worship rituals differed between the various religions. For some, these rituals were invested almost completely in the priests while others relied heavily on personal or familial observances. In some religions, the priests claim to speak for God or to be appointed, or called, by God to act as the official liaison between the common people and the Deity, whereas in other religions, they are simply regarded as experts in their particular faith.

In addition to holy books, rituals, and a cast of people to administer the rituals, all religions share several assumptions that have been inherited from ancient times, and even though we now know far more about the Universe than the ancients could have ever imagined, nearly all of these assumptions made by the ancients are still part of modern beliefs.

The first of these assumptions is that the Universe (the Earth to the ancients; the *Book of Genesis* implies that the Earth is all there is to non-heavenly creation.) was created by a supernatural power. This is a natural assumption common to all religions. Only atheists, who deny the existence of a Supreme Being, reject it.

Another assumption is that the Universe (the Earth to the ancients) is composed of only what we see. This was a very reasonable assumption for those times of ignorance. The only difference between us and the ancients is that we are now privileged to see more. However, no religion has yet come to terms with our new understanding of the enormous size of the Universe; the Deity is not merely the God of Abraham and Isaac and the God who sent the angel Gabriel to give the *Qur'an* to Muhammad and sent the angel Moroni to give the *Book of Mormon* to Joseph Smith, but is the God of billions of galaxies each containing billions of stars. However, the truth that we are only a tiny drop in a rain barrel is not something that 99% of us want to hear.

A third assumption is that the Universe (the Earth to the ancients) was created exactly as we see it; it has never looked any different than it does now. Because of their lack of knowledge, the ancients could not possibly have understood how bad this assumption is. Even in the third millennium, many people who live in remote places and are not familiar with the expansion of knowledge in the twentieth century probably still cling to this old assumption. Because this new knowledge disagrees with scripture, many people who do have access to the modern advances in knowledge still choose to reject that the Earth is 4.7 billion years old and has experienced innumerable changes, preferring instead to be as ignorant as folks were thousands of years ago. This is nothing less than a rejection of the natural laws that the Almighty created and thus, in a sense, a rejection of God.

The first person known to have abandoned the ubiquitous polytheistic nature religions of the ancients in favor of a single Creator was Abraham, the patriarch of the Hebrews and Arabs, who call him Ibrahim. Abraham created a new religious paradigm, which he required all in his household to observe and which he passed on to his children. During the eons since

Abraham introduced this new paradigm, it has dominated thought in the religions of the West, but some of the polytheistic religions of the ancients remain.

All religions attempt to address the issue of suffering and evil because they recognize the seeming contradiction that a benevolent, all-powerful, all-knowing Supreme Being allows suffering and evil to exist. This apparent contradiction has been used by some to deny the existence of God. In the minds of some people, religion has been unable to come to grips with the existence of suffering, so they turn to Buddhism, which as described earlier, is a system for dealing with suffering. The problem of evil has been addressed by philosophers of religion with varying degrees of success. It's questionable that a satisfactory resolution of the problem of evil will ever be found within the context of religion and philosophy because philosophers argue from the position of our limited space-time-energy/matter existence, whereas the Supreme Being is far beyond that. Doubtless, philosophers disagree.

Although, with the exception of Islam, violence in the name of faith is not an official policy of any religion, the faithful have often resorted to it. While not directly commanding the believers to violence, all holy writings, with the exception of the Christian Bible, contain accounts that glorify violence in the name of faith. Perhaps the most well known is the Battle of Jericho, the first battle of the Israelites during their conquest of Canaan, which is described in the biblical *Book of Joshua*, (Joshua 6:1-27). Although direct commands to fight on behalf of the faith are notably absent from the Bible, Christians have historically been quite willing to make war on their own initiative, and the crusades of the Middle Ages is an excellent example. The predilection of Christians to fight for their beliefs extends to occasionally warring among themselves.

Although war is prominent in some Hindu sacred texts such as the *Bhagavad Gita*, warfare in Hindu texts is a battle for secular control and not a struggle in the name of faith. For example, in the *Bhagavad Gita*, the warfare depicted is the Kurukshetra War for supremacy in the dynasty of Kuru kings between the Kauravas and Pandavas, two groups of cousins. It is simply an incidental setting for a dialog between the Pandava prince Arjuna and his charioteer, who happens to be Lord Krishna in disguise, on philosophical principles such as honor and duty. Of all the holy books, only the *Qur'an* officially promotes fighting on behalf of faith. See Chapter 11.

All religions share several common characteristics:

1. A belief in a supernatural creator of the Universe;
2. A story describing how the Supernatural power created the Universe;
3. A story describing the relationship between people and the Creator;
4. A belief in an afterlife and a concomitant concern for burial practices;
5. If a literate religion, a set of holy books that detail religious beliefs;
6. A belief that the religion was given to mankind by the supernatural creator or agent thereof;
7. A belief that the supernatural creator controls the unfolding of the Universe to some degree;

8. And a belief that the supernatural creator can successfully be beseeched for personal favors.

These characteristics were all present even in the primitive religions of our ancestors.

From the Catholic Church's persecution of Galileo over his stand in favor of a universe centered on the Sun rather than on the Earth to modern fundamentalist denigration of the Theory of Evolution, religion has fought with science. In a rational sense, this struggle is difficult to understand because science and religion focus on different, non-overlapping issues: science is interested in understanding the Universe as it's given to us whereas religion addresses our relationship with the Creator, which science emphatically declares to be outside its purview. Science refuses to say anything about a supernatural God. However, without intending to do so, science's Theory of Evolution strikes at the heart of religion's basic assumption that the human race has a special relationship with God. Perhaps the struggle between religion and science is best understood from an evolutionary perspective as the alpha-driven struggle to control men's minds.