First, a few personal remarks.
In the final decade of the 20\textsuperscript{th} century I had the rare opportunity to teach a course of my own making. It was supposed to be a course in the history of physics for non-science students, but by that time I had acquired certain philosophical convictions about physics, about science in general; and also certain skepticism about the practicality, or even the desirability, of Modern Civilization. These convictions were at odds with the doctrines with which I had been inculcated as a teenager, and later as a physicist. My own outlook can be best described as\textit{generalist}--I respond to inputs across the entire spectrum of human experience. I confess to having a special affection for the later writings of Aldous Huxley.

So, at long last I had the opportunity to say that in which I really believed, and better, to discuss these forbidden subjects in class. I simply couldn’t pass up the chance. In order that its syllabus might sail past the eyes of the people on the relevant committees, I disguised the course as an irreverent survey of the history of science leading up to, and including, the development of the Quantum Theory.

The centerpiece of the course was a discussion of a crucial experiment that had been performed at the University of Paris in the late 1970’s, to verify whether or not what is called Bell’s Theorem is indeed obeyed in Nature. This topic sounded innocuous enough, but I knew full well that it had (and has) a significance that undermines centuries of western philosophy. It was a kind of Trojan horse.

Why? At some point in his life Albert Einstein had written the following words, expressing that which seems to agree with day-to-day experience:

\begin{quote}
“The belief in an external world, independent of the perceiving subject, is the basis of all natural science.”
\end{quote}

But the results of the Paris experiments had indicated clearly that this statement was\textit{wrong}! And since that time, many similar experiments have shown consistently that the results obtained in Paris are correct, and that Einstein was\textit{still wrong}!

What Einstein had so eloquently written was just the tip of the proverbial iceberg. For decades I had been exposed to a world where materialist reductionism was a central article of religion; where humans are mere “gypsies marooned on the edge of a universe oblivious to their presence”—the stuff I used to see in 1950’s science fiction. Adherence to these doctrines was, and still is, a fig leaf of intellectual respectability among those who work in science. You might ask: “Do you mean that materialist reductionism is really a kind of religious fundamentalism?” And I will nod vigorously: “Yes, with all my heart. And I have come here to advocate heresy!”

The result of my effort was a book, used as a text, entitled: \textit{“The Conscious Universe.”} I had but a few months’ time before classes started, and had never before attempted a thing like this. So I worked at breakneck speed. Those were heady times, and the new course was a roaring success.
Years passed, and I retired from my professorship; but one day, quite by accident, I discovered that the book had retained a kind of “underground cult following.” So I was persuaded to clean up the many typographical errors and put the material ‘on line.’ Probably, I should have dragged the book out of mothballs, and “let it fly, warts and all.” After all, no less a writer than Walt Whitman, (influenced by a line in the Hebrew Bible), counseled that the best policy upon finishing a work is to turn one’s back and walk away. But I couldn’t bring myself to do this. As a result the reader will find that there have been certain additions and subtractions. I hope that I will be forgiven. So, I made some alterations:

1. I eliminated all the Review Questions from the ends of the chapters. Why? Because there will be no more examinations. This is not a textbook any more; it is an inducement to heresy.
2. In the later chapters there are no endnotes. I have come to doubt whether anyone reads those things.
3. I have tried to tone down the academic prose. It was a kind of cover-up, in case one of my colleagues should be tempted to read the book.
4. The earlier chapters still have a touch of academia to them. Sorry about that.

The main thrust in this book is to try to convince you that the society in which we live is absurd, that it is a ‘Wasteland,’ in the sense that T.S. Eliot meant, when he wrote that poem. During the ‘60s a film appeared, called ‘The Graduate.’ If poetry doesn’t appeal to you, you might want to start by renting the cassette.

In answer to the question: “Do you still hold the same opinions that you held at the time you were working on the original edition of the book?” I answer: “Yes, I remain unredeemable in that regard.” But the style I had felt to be appropriate for a college textbook is no longer really appropriate, (if it ever was). It was part of my ‘persona’ while I was playing the role of ‘professor;’ (and I was getting tired of it). One of the chapters, (number 13 in the original addition) has been ‘demoted’ to the status of Appendix F, for those who are interested in so-called:’particle physics.’ Further, in the chapters dealing with Psi, I am relying on the hope that you will purchase and read a number of the books by great people like Dean Radin and Russell Targ. There is too much precious material there for me even to attempt to cover. Besides, it would probably be illegal!

Between the original book and this one lie the events of 11 September 2001, together with its aftermath: the abrupt decline of America as a constitutional republic, the return of this country to its pre-New Deal ‘default setting,’ the decline of the University to the status of a sports program attached to a ‘business college,’ and the looming prospect of economic collapse. All of these events have the character of omens, showing that Aldous Huxley, my spirit guide, was right.
INTRODUCTION

We are like flies crawling across the ceiling of the Sistine Chapel: We cannot see
What angels and gods lie underneath the threshold of our perceptions. We do not
live in reality; we live in our paradigms, our habituated perceptions, our illusions.
The illusions we share through culture we call reality, but the true historical reality
of our condition is unknown to us.

William Irwin Thompson

Although the idea may seem counterintuitive, the position taken in this book is that our understanding of
the world is actually obtained through the medium of Myth. What, actually is a myth? For one thing, it is
not synonymous with an untruth. A myth is a story line, one that serves to unfold the world-view of a
given culture. It can be said that a culture is made up of the totality of those persons who act out the
story line of the myth. What, then, are the ingredients of the grand cultural myth? I believe that the best
summary is that written by the artist, Paul Gauguin:

Who are we? Where do we come from?
Where are we going?

In the earlier edition of this book, I listed four ingredients of that story line. It must contain: (1) a
presentation of The Official Creation Myth, a description of how the world came into being: (2) a
description of how the people and their culture came to exist: (3) an apocalyptic element, forecasting our
cultural destiny: (4) finally, a part of the myth prescribing what actions we must take in order to
function properly as actors in the story line. Thus the myth provides the ‘script,’ showing us our
prescribed roles in the unrolling story line—those actions that we perform on a daily basis. Although the
myth’s content contains a heavy dose of fiction, we must not assume that it is unalloyed falsehood,
either. Rather, it is an artful blend of fable, with just enough of fact built into its structure to ensure its
stability. If you would like an example that is ‘close to home,’ consider America, as ‘a city on a hill,’ a
metaphor used by John Winthrop in, (I believe), 1627, as his ship, the Arabella, was on its way to The
Massachusetts Colony. There is a lot of food for thought there, if you are gifted with robust digestion.

The mythic structure underlying Modern Civilization is one that is quite rich and complex; but much of
it was put in place during the seventeenth century by just six people: Galileo Galilei, René Descartes,
Francis Bacon, Isaac Newton, Thomas Hobbes and John Locke. Their contributions will be discussed in
Chapters Two, Four, Five and Six. Since that time it has been necessary to create several amendments to
the original scenario; but it is really uncanny, how the original, gut-level content of that story line has
persisted in spite of everything. Even now, at a time when The Myth shows unmistakable signs of
unraveling, the worldview created by these six gentlemen has infiltrated our way of thinking to such an
extent that it still be found at any time on the pages of the New York Times or The Wall Street Journal.
Myth is neither a friend nor an enemy. And it is, up to a point, indispensible. But past that point it becomes a ‘false friend.’ This is because Myth is essential for action; it operates at the gut level. We must mythologize in order to live. If we, like certain thinkers in the past, refuse to recite our lines from the official script and ‘go off-message,’ then there will be consequences: for one thing, we will be forced to create and act out a myth of our own making. In addition, in our conversations with other people, uncomfortable moments will often occur, often producing social marginalization. However miserable the melody, we are expected to sing in unison!

Why is this true? Someone once remarked that in this country most people are “either Protestant or Catholic, either Democrats or Republicans.” These categories are like little boxes: and act as a form of Social Control, deterrents to actual thinking. To think outside the box requires effort—and often a certain amount of dissembling.

No two persons will produce exactly the same version of The Central Myth of Western Civilization, but it is easy to compose a “short list” of essential ingredients. Here are some of them:

1) The human race is the final inheritor of the world.
2) Modern Civilization provides the final pattern for the way in which people are going to live.
3) Modern Civilization will last forever, (or for millennia, at least), and our situation is constantly improving.
4) It is our duty to do our best to see that the above happens.
5) Domestication is our destiny. We domesticate plants and other animals. We must not shrink from submitting to domesticating ourselves.
6) The world we have inherited is devoid of intrinsic significance and value; (“undeveloped,” is the popular euphemism), except for whatever significance that humans deign to bestow upon it.
7) It is the right and duty of humans to give meaning to the planet by making it over in our own image, thereby increasing the ‘order’ of the world.
8) We inhabit a world that is composed of objects, (a world of nouns) having properties that are intrinsic, that is: independent of any beings that experience them, (a concept called “radical atomism”).” The only real knowledge is objective knowledge.
9) The behavior of every object can always be explained in terms of the behavior of its parts.
10) The scientific method is “omnicompetent.” The laws of science as we know it today are final and exhaustive. That is: the roster of laws needs no further extension.

In direct contradiction to the mythic story line, I assert that human activity does not increase the order of the world; it actually decreases that order. Artifacts such as cities represent islands of order created at the expense of the rest of the planet, which thereby suffers a disproportionately greater degree of disorder.
In 1959 Writer Aldous Huxley delivered a series of lectures at The University of California at Santa Barbara, entitled The Human Situation. In one of these lectures, entitled: Man and His Planet, Huxley chronicled the deforestation of Europe and North America, reminding us that Provence, whose present semi-arid landscape was so powerfully depicted by painter Paul Cezanne, had actually been covered by dense forests, up until Roman times. Huxley was quite explicit about the theme of his lecture:

**Forests precede Civilization; deserts follow.**

That remark was made at the end of the eighteenth century, by François de Chateaubriand, who was watching barges laden with firewood, as they moved down the Seine to Paris. The consequences, if this is true, are nothing short of devastating. For one thing, it directly contradicts the Central Myth of Modern Civilization; for then, how can Civilization, seen as a project, be worth carrying out? If the final result of Civilization is the sucking of the life from the planet, and if we have been conditioned to require Civilization for our daily sustenance, then we have been relegated to the status of crewmembers on a self-destroying machine. I had not realized it at the time, but this scenario bears a certain resemblance to the plot of that greatest of all American novels: *Moby Dick*! In the latter case the whaling ship *Pequod* is a metaphor for America. Writer Chris Hedges’ analysis of this novel is Required Reading for understanding life in America.

At this point we need to make an excursion into the field of astronomy, because the career of a civilization bears a certain resemblance to that of a star. They both must burn fuel in order to live. A star, as it goes through its cycle, burns its own substance as fuel. At first, a civilization obtains fuel by plundering its neighbors. When this is no longer possible, it is the beginning of the end. But Civilization in general is really only a parasite on the planet.

One of the most challenging aspects of the Great Myth is the notion that the universe is, for practical purposes, comprehensible to the human intellect.

You have probably heard of the Faust legend: about a philosopher-alchemist in the Renaissance, who is said to have sold his soul to the Devil in trade for infinite power. This legend, a Myth For Our Time, has been immortalized in literature for over four centuries. I shall try to make the case that it is not unreasonable to describe Western Civilization as a “Faustian Culture.” So, to what extent has the Devil lived up to his share of that bargain? The answer is: *all too well.*

For the Faust story has for, us, a more sober sequel. It has given rise to a turn of phrase in the English language, namely: ‘The Faustian Bargain’. For our purposes, it means that you get to do what you ask for—but you are damned if you try to stop doing it. This, from Goethe’s *Faust* (my translation) is
Faust’s bargain with Mephistopheles:

“Shake on it!
If I e’er say to the passing moment:
‘Stay yet a while, so fair thou art,
Then you may throw me in chains!’”

Our pursuit of science has given us material progress, (economic growth), as well as the illusion of control. But we can’t stop without mass starvation, nor can we continue to go forward. If I insist on having growth, I have become a cancer upon the world. We do not have a problem here; what we have instead, is a predicament, for it is we who constitute the problem!

The beginning of the twentieth century marked the birth of the Quantum Theory. However, more than a quarter-century of inspired work was necessary before physicists began to realize that they had to come to terms with a strange and rebellious child. To date, the theory, now grown to maturity, has successfully beaten back all challengers. It is the most comprehensive, the most successful theory that scientists have ever produced. But it was the Quantum Theory that made it clear that nature is not visualizeable, because nature is not a thing ‘out there.’ It is no longer possible to separate the subject of a sentence from the object in a consistent manner. Nature is a vast mosaic of events, of which ‘we’ form but a part.

Finally, in response to that list of ingredients of The Central Myth: They are not even wrong. They may have, at one time, had their use, but now they are merely gibberish.
CHAPTER ONE
THE HUMAN CONDITION
A Revisionist History

What is History, but a lie agreed upon?
Napoleon

History will be kind to me, for I shall write it myself.
Winston Churchill

We must stand apart from the conventions of history, even while using the record of the past, for the idea of history is itself a western invention whose central theme is the rejection of habitat. It formulates experience outside of nature and tends to reduce place to only a stage upon which the human drama is enacted. History conceives the past mainly in terms of biography and nations. It seeks causality in the conscious, spiritual, ambitious character of men and memorializes them in writing.
Paul Shepard
Traces of an Omnivore ¹

As we saw in the Introduction, every culture is an expression of a particular Myth. The most famous example of this is the story told in chapters 1-3 in The Book Of Genesis, a kind of creation myth that has exerted its power for more that 3,000 years, and has formed a rather shaky foundation for at least three major world religions. Another such myth is Modern Civilization’s creation myth, the story of the evolutionary rise of “man”, Ultimate Master of the Universe. It must be added that this story bears a curious resemblance to the biblical myth, even while rejecting it. Both stories constitute the anthropocentric view par excellence: an earth made for us to rule. Instead, is it not more reasonable to assume that we are ultimately subject to the same rules that govern the other living species? To appreciate the extent to which the standard myth withholds the truth from us, it would be wise to start with a discussion of the facts of life, followed by a bit of family history.

First, The Dance Of Life and Death

We begin with a description of the fundamental facts of our biological existence — those concerning Life and Death. Although misrepresented to us as polar opposites, the two are really in a reciprocal relationship; like the two sides of a coin, neither can exist without the other. They are each part of a larger process. But Civilization promotes the fallacy that we can exempt ourselves indefinitely from the Game Of Life, which includes taking our place in The Food Chain. We have been taught to think of Civilization as a bulwark erected over the ages by humankind, a protection from chaos, from a patently hostile nature, and against nature's agent: Death. If not an outright lie, it is certainly a gross distortion of the truth. For although individual lives are short, Life itself is very old; on this planet it has had a long run of over 3.5 billion years. What, then, is the significance of the loss of an individual life? An eloquent reply to this question is given by the poet Gary Snyder:

All of nature is a gift-exchange, a potluck banquet, and there is no death that is not somebody’s food, no life that is not somebody’s death. Is this a flaw in the universe? A sign of the sullied condition of being? “nature red in tooth and claw”? Some
people read it this way, leading to a disgust with self, with humanity, and with life itself. They are on the wrong fork of the path.

For life to continue in perpetuity, the food chain must always close upon itself. Life can be thought of as a kind of game; but if one of the players is allowed to gain a final victory, the game of life is over, evolution comes to an end, and the planet dies. Like the game of Monopoly when one player owns everything on the board: no one can play any more. It is in this light that we must view Civilization: it is an attempt to evade, to “beat” the game of life. It is really this life-denying characteristic that makes Civilization dysfunctional. All of its other prevarications are ancillary to this one.

Terrence des Pres, in his study of factors promoting survival in concentration camps has described the human predicament eloquently in the following words:

Civilization has long passed the immediacy of the survival situation (for those at the top, that is); its ancient roots are hidden, deliberately obscured. The function of technology is to serve physical and economic needs well enough for us to ignore them. The function of culture is to negate the primal facts of nothingness and death. Both aspects of civilization reduce consciousness of our condition as biological creatures. And in the end both breed contempt for life.... Western civilization is the negation of biological reality; and unavoidably, since life and death are inextricable, the denial of death comes finally to be a denial of life....

Two Absolutely Necessary Concepts For Achieving An Understanding Of The Limits Of Civilization

At this point in our story it is necessary for us to master, that is to learn to employ, two vitally important concepts, ones without which no understanding of the human condition is possible. The first of these is the concepts of the “Quasi-solution” and the "Residue Problems." Everyone who has ever sat in the seat of power has discovered this ineluctable limitation, and it determines the ultimate fate of all administrative "programs," no matter how well intentioned. In many ways this limitation is really a consequence of the Second Law of Thermodynamics.

It is not difficult to find examples of these consequences:

“The Quasi-solution”. It is a matter of empirical observation that “techno-social” attempts to solve problems (“techno-fixes”) never seem to produce long-term solutions. Instead, in the wake of these attempts there arise yet other problems, some of which have actually been spawned by misguided attempts to find solutions. Such second-order problems—unanticipated consequences— are called:

“Residue Problems”. These new problems will proliferate at a faster rate than solutions can be found to meet them. The residue of unsolved techno-social problems converges in an advanced technological society to a point where techno-social solutions are no longer possible. It is no exaggeration to list these among the basic facts of life.

Quasi-solutions and Residue Problems are everywhere around us. Consider for example the resistance developed by the bacterium, Staphylococcus aureus to the entire armamentarium of antibiotics (Quasi-solutions) produced by the pharmaceutical industry. In any population of bacteria there will always be some individuals, which, by virtue of genetic variation, will display an enhanced ability to resist attacks by antibiotic fungi. These, the “unreasonably effective” bacteria, having a competitive edge over those who are less “fit”, will be the ones that go on to replicate their kind. For a while, each time a resistant strain was found, the pharmaceutical industry was able to counter the threat with a more powerful, more expensive antibiotic. But not any longer. For the present, we seem to have arrived at the end of the line, at least for this particular type of antibiotic. Therefore we must conclude that, in its efforts to eradicate
disease, so far “scientific medicine” has really been operating a training camp for an army of more effective, drug-resistant bacteria, (Residue Problems). The same kind of thing happens when radiation and chemotherapy are used upon a person suffering from cancer. Bacteria and cancer cells are part of life, too; and they also evolve, even if the religious fundamentalists prefer to ignore this.

Predicaments such as those which are described above, together with the driving force of overpopulation, are among those which combine to place a boundary condition upon human life; for although we are still “unreasonably effective animals”, it is Nature who really does ‘bat last.’ The poet Walt Whitman expressed this element of the Human Situation in the following manner:

> It is provided in the essence of things that from any fruition of success, no matter what, shall come forth something to make a greater struggle necessary.

Ultimately this is the nature of the Game Of Life; but for us it is a statement of the human predicament. We cannot indefinitely escape the conditions placed upon us by nature. With this in mind, let us move on to a brief review of the history of the human family.

What the Paleontologists and Anthropologists Are Saying About Us

It is possible to make an intelligent conjecture that, at some point “in the time before there was time”, a scenario was enacted that is similar to the following one: one of our ancestors seems to have scrambled warily down from the trees and stood there, staring in mute un-comprehension over the vast expanse of the great Serengeti Plain, as it throbbed under the impact of the hooves of great herds of antelope and wildebeeste. At first our forebears were forced to content themselves scavenging the kills of the leopard, the hyena and the lion. But the slow passage of hundreds of millennia would bring to them the strength and the skill to become hunters in their own right. By that time the other predators had begun to defer to the primates who, like them, hunted in packs, and were becoming armed with progressively more effective weapons. The initial invasion of the Savannah seems to have occurred some three, or possibly as many as four million years ago; at least the presently available evidence seems to point in that direction.

Hunting and gathering duly became our family profession. Agriculture, on the other hand, is a relatively recent invention, having become a more or less exclusive way of life a mere 10,000 years ago: a mere 400 human generations! By contrast, in four million years there are 160,000 generations: 400 times 400 generations! One way to visualize this vast gulf is to think of it in terms of a twenty-four hour day. If the day, (one second after midnight) had begun in that first moment on the Serengeti, the regular practice of agriculture would not commence until less than four minutes before the following midnight. But we must never forget that the clock of mutation ticks much more slowly than this; with the result that the human genome differs from that of our cousin the chimpanzee (also a hunter-gatherer), by no more than a mere one percent. Indeed, of the 146 amino acids of the Beta chain of blood hemoglobin, the gorilla differs from the human at only one isolated site upon the molecule.

Stop the Presses!

As I write these words it is June 2013. Within the past two years an article on the structure of DNA has appeared in my favorite science magazine, Science News. For years we had all been under the impression that the only useful parts of the DNA molecule were those containing gene sites. The vast regions of the molecule between those sites were referred to dismissively as “junk DNA.” Not any more. Instead, it has been found that these regions constitute a prolific source of RNA, and moreover, human RNA differs significantly from that of our fellow primates. That said, there is still no reason to believe that Mother Nature ever engineered us to watch TV, play video games and cruise for ‘burgers. It will
require a major genetic engineering breakthrough, by which time the electronics and the gasoline will have become extinct.

From this fact it follows that our inherited genetic structure is not too different from what it was at the time of that fateful crossing onto the savannah. Although it is true that our brains are indeed larger than those of the earliest hunter-gatherers, the underlying structures such as the amygdala and the hypothalamus are set by the rules of the ancient genome. Further, we happen to share the architecture of these structures—the same structures that regulate the basic life processes, with individuals in numerous other species. As a result of the iterative, jerry-building character of evolution whereby older architecture is modified to serve newer purposes, these ancient organs continue to modulate the development and adult activity of other, more modern structures of the brain. Biologically then, we still "have one foot in the Pleistocene," as it were; and we carry that forgotten time about within us, even while trying to negotiate a traffic jam on a hot Friday afternoon, wrestling with a mathematics problem, or playing the alienating game of Civilization, trying to obtain an abstract thing called “employment”, as a means to gaining another abstraction, called: “money”. Therefore it is with this Pleistocene Identity that we must come to terms; it is this identity that structures the blood that runs in our arteries, patterns our endocrine and immune systems, and demands to have its say in the function of our brains. Never mind that the requirements of hunting and gathering made it imperative that the evolving primates should ultimately develop the reasoning powers necessary to hunt animals and to cultivate medicinal and psychotropic plants. These requirements also enabled them to create exquisite hand-axes, javelins and state-of-the-art arrowheads, and to construct clothing and boats out of hides. It was in this one-step-at-a-time manner, that primates came to depend on technology; and each time, it was born out of need. Instead of following the path taken by Life for billions of years, by evolving biologically in response to the changes occurring in their natural environment, the primates, now having become human, began to compensate by constructing technological fixes, adjusting the environment to their needs. It was like constructing a giant snail's shell. It didn't happen all at once, for a nomadic person can only carry about forty pounds on his or her back. But once humans became more sedentary, they became imprisoned by their own technology, in a kind of gulag of their own design. From this it seems clear: we were not originally constructed to live in the Modern World. Thus it is imperative that we recognize the hunter and the gatherer as being closer to our true likeness than is, for example, the over-stressed mid-level executive. The denial of our primordial nature is a misrepresentation of our very selves.

Now that we have recognized our origins, as well as something of our true nature, it should not be difficult to arrive at the humbling realization that our distant, primate ancestor did not really arrive on terra firma with a copy of The Official Blueprint For The Universe tucked under one hairy arm. Thus, it should not be surprising if we, despite the brilliant discoveries that have been made, are still mystified.

The Fall From Grace

At this point the question inevitably arises: What was it that occasioned the fall from Grace, that descent from the pursuit of the deer and the aurochs, the ecstatic cave drawings, down the slippery slope of domestication to the deadening monotony of peasant life, a life lived constantly at the mercy of invaders and tax-collectors? Even today we have to use force to herd indigenous people off their land, into the squalor of life in huts roofed with corrugated iron, on the outskirts of teeming megalopolises. They seldom submit peaceably. In short, if hunting and gathering were so much fun, why did we ever stop?

At this point, (Sept. 2012), I must add something. There is a book: War Before Civilization, by Lawrence Keeley, who is an archeologist. He has examined many prehistoric “military cemeteries,” and he and his colleagues have examined hundreds of human remains: adults and infants, males and females. The verdict is one of genocide. He concludes that constant feuding was endemic between tribal groups. Moreover, in places like New Guinea, the same kind of thing goes on today. There is a terrible lesson to be learned: We humans are often a murderous bunch. And we are like that even today. Sometimes we
can go on for a long time without a nice, friendly massacre, (the Swiss are said not to have fought a war in the past 200 years, and until they were attacked by the Iraqis in the 1980s, the same thing was true of the Iranians. What excuse can we offer for this uncomfortable fact? The prevailing evidence suggests that we share a common ancestor with the chimpanzee, who possesses warlike characteristics very similar to ours. In short, it’s in our very nature! If we could have chosen our own ancestors, we might have done better to choose the bonobo, another member of the primate line. Why? That would be a good assignment for you!

But the most believable explanation of The Fall is that societies in general, including archaic ones, have been compelled to change, not as a result of an advance in the quality of life, but rather as a result of the progressive deterioration of that very quality, brought about by increased population density and the resulting struggle for power and space. This aspect of the human predicament can be called “circumscription”; for truly, humans are “circumscribed” by progressively tighter crowding, food shortages, as well as by the concomitant environmental deterioration and increase of governmental control. Humans do not really seem to have taken up the agricultural life all at once. For centuries they apparently lived a mixed existence; there is even some suspicion that the first plants systematically cultivated were of a psychotropic nature.

A life on the farm is one whereby hard, repetitious labor can produce a series of bountiful harvests and huge surpluses of food, (though usually deficient in variety), punctuated at times by intervals of devastating famine. Early on in the history of this venture it became necessary to protect the precious foodstuffs from marauders such as humans, rodents and insects. To this end granaries were established, and even the earliest of these were protected by high walls, and defended by armies of soldiers. But full dependence upon agriculture would also demand drastic amounts of social regimentation; thus the demographic crisis that brought about agriculture in turn necessitated the invention of Civilization. With the arrival of Civilization, also came what is called a "vertical" social structure: one that is by its nature bureaucratic, hierarchical. The chain of command extended, on up the ladder of officials minor and major, up to the King. In turn the King, held to be a descendant of the Sky God, and consecrated by the priests, was ruler of the cosmos, and ultimate arbiter of What Is Right. As these civilizations developed, exhaustion of the soil inevitably followed, and it became necessary for them to acquire more food by conquering their neighbors. But the ability to wage organized war made necessary the maintenance of standing armies; this in turn placed more and more pressure on the farmers who, besides feeding themselves, were forced to feed progressively larger numbers of soldiers and bureaucratic functionaries. There seems to be an ironclad rule, which dictates that such societies must either conquer or be conquered by others. Several examples of this pattern have been examined in a recent book by Allen Johnson and Timothy Earl.

The authors conclude that the engine driving the human race along the road from family-level foraging through the agrarian state to regional polity and the nation-state has been powered by endless rounds of population increases and the concomitant intensification of crop practices. Of particular significance is their remark:

Integration on a massive regional or interregional scale is a defining characteristic of states. Minimally this integration involves a bureaucracy, a Military establishment, and an institutionalized state religion.

The Origins Of Organized Religion In The Vertically-Integrated Civilizations

This last point is an especially important one: it seems that there was no such thing as Organized Religion before the advent of Civilization. Once kingship was invented, it became necessary to legitimize the rule of the king by harmonizing the polis with the cosmos--guaranteeing the celestial legitimacy of the government as an engine of Control: what philosopher Stephen Toulmin called the
Cosmopolis, and what writer Lewis Mumford called The Megamachine. This task was the responsibility of the priests. Hence organized religion is really an artifact of the state; and has no legitimate function independent of the state. Before the coming of the agrarian civilizations the mediator between the tribes-people and the unknown powers of Nature was the shaman, a member of the tribe who functioned as psychiatrist and medical doctor, as well as intermediary with the spirit world. But the traditional enemy of the shaman has always been the priest, and in due course the shamans were driven beyond the margins of Civilization. As we shall learn, with the passage of time this increase in social organization brought about a progressive invasion of the human psyche by the purveyors of organized religion, as well as a devaluation of the Unconscious Mind.

Those who have studied the ways of hunter-gatherers have discovered profound similarities among them everywhere. These similarities also hold in the case of subsistence farmers, pastoralists, and urban peoples, each taken as a group. What is most noticeable is that religious philosophies and cultural patterns of otherwise distant peoples seem to converge, together with their ecological patterns. From these interrelations it is possible for us to understand how it was that, as the fortunes of the civilizations, (together with their religions) rose, the fortunes of the hunter-gatherers and their shamans fell. Just as the temporal power of the rulers, exercised through the state bureaucracy, “circumscribed” the day-to-day activities of the citizens, the priests went on to extend control over their spiritual lives.

**Agriculture--An Example Of A Quasi-solution**

Curious as it may seem, the human race, in its role of Sorcerer’s Apprentice, is still paying dearly for the invention of agriculture, as innocuous as it may have seemed to its practitioners at the time. For agriculture is a perfect example of a Quasi-solution, with the inevitable retinue of Residue Problems that followed in its train. It happened in this manner. A sedentary existence brought with it an increased birth rate, since among nomads consecutive children must be spaced four years apart; otherwise the child is unable to move with its parents. This implies that sedentary, that is, agricultural civilizations, are inherently unstable. With the growth of the population it became necessary to expand the area of fields under cultivation, until no more arable land could be found. This is why the agricultural civilizations necessarily took on an expansionist character. Actually, it can be easily shown that all unstable societies must necessarily be expansionist—until they collapse. (Ours is one of those!) Occasionally empires would make war upon each other; but it was easier to prey on the remaining hunter-gatherers, driving them ever farther into the forests. Ultimately the central bureaucracies increased in size and complexity, in turn raising the burden of taxes upon the tillers of the soil. With time the surrounding land became incapable of supporting the voracious appetite of the cities, and the whole enterprise simply collapsed. There is abundant evidence in the archeological record indicating that this scenario has been enacted repeatedly in the past. But it must be said here that all civilizations are fundamentally agricultural, including ours. Whatever advances may occur in computer technology, it must be recognized that one cannot eat silicon. Thus from the foregoing, we are led to the following conclusion: All Complex Societies eventually collapse under their own weight.

The above is an example of the Second Law of Thermodynamics, to which there are no known exceptions. In physiological metabolism we burn food (oxidize it), in order to carry out the activities of life. In addition we burn fuel for warmth, or (in much of the world), for air-conditioning. We also burn fuel to refine ores, to make beer, pasteurize milk, and perform hundreds of other tasks. For the moment we are sustained by the use of coal, gas and oil—“ancient sunlight.” When the fuel supply gives out, as it inevitably will, our Civilization will die. Any survivors will be those who can make use of renewable resources. That is the Law. At the time of this revision, (August 2012), it has become clear that 8 billion people, freely using “ancient sunlight” will, within the lifetime of my children, make the earth uninhabitable for most of their number. At the end, the earth’s carbon reserves will remain—remain useless.
How The Decline Of European Civilization At The End Of The Middle Ages Follows From The Second Law, Of Which The Law Of Malthus Is A Corollary

Thus far, we have learned the overriding importance of the interplay between human demographics and the rest of the ecological picture, and we have arrived at a vantage point from which it is possible to understand the growth and decline of Complex Societies in general. An example that is of particular interest to us is the trajectory of Medieval Civilization in Europe, which in its declining phase set the stage for that condition of continuous crisis which, for want of a better name, we call: Modern Civilization.

It is generally accepted that in Europe the Medieval World had reached its zenith shortly after the middle of the 12th century. Some have called this period "The 12th century Renaissance" Milder climatic conditions, coupled with inventions such as the steel-shod plow, the iron horse-shoe and the horse-collars, all made it possible to bring a great deal of marginal land into cultivation. It was the time of the growth of towns, and the construction of great cathedrals; the music of the Gregorian Chant was being heard in hundreds of newly constructed abbeys and monasteries throughout Europe. At that time, for a male in Western Europe, life expectancy had risen to 55 years, compared to a mere 25 years during the years of the Roman Empire. However, the benevolence of nature during that period brought in its wake a corresponding increase in the human population. And there, of course, was the rub. If we focus our attention upon the region stretching from the valley of the Seine north to the Low Countries, the following estimates are available: At the end of the seventh century, probably the nadir of the Dark Ages, the population had fallen, as a result of famine, plague and murder, to about two-and-a-half million. By the year 1000 the population had rebounded to six million, rising to an astonishing figure of 19 million by the year 1300! However, the inevitable ecological disaster was soon to follow. After the close of the 12th century, further agricultural improvements had no longer been forthcoming, and the 14th century was ushered in by the unexpected onset of a cold and rainy climate, a condition, which would persist for centuries. It was the beginning of the Little Ice Age. Significantly, between AD 1100 and AD 1350, although the average yields of cereal grains had doubled in Europe, the human population had already quadrupled.

To make matters worse, Medieval Civilization itself had become more complex and socially stratified — and thus correspondingly less productive and less adaptable.

In 1337 a dynastic dispute, one that had arisen over the right to sit upon the throne of France, erupted into a war of succession between that country and England: The Hundred Years’ War. Eleven years after the outbreak of war, the Black Death struck Europe, carrying away at least one-third of its people, leaving the survivors demoralized. Up until this time the steady growth of the human population had been placing an ever-increasing strain upon the European ecosystem. Indeed, the need to pay taxes to support the growing urban and military superstructure had made it impossible for farmers to leave the fields fallow long enough to secure their recovery before replanting. However disastrous The Plague proved to be for the human population, it must be said that it provided a much-needed, but all too short-lived respite for the ecosystem in Europe. And for all its virulence, the plague proved unable to return that ecosystem to a state of balance.

Throughout the 14th century, war, famine and plague had taken their psychological toll throughout Europe. Moreover, the Roman Church, which had been a kind of axle around which medieval civilization had been turning for over a thousand years, had sunk into a state of decadence. A sort of schism in the Church had existed for a long time and the institution actually appeared to be moribund. At those times, there were some remarkable people who could see that the medieval civilization had lost its way and that it was wise to consult the road map, in the hope that they would be able to see where they had taken the wrong turn. It happened in Italy—in Florence to be exact, shortly after the year 1400: a wealthy family of Florentine bankers, the Medici, became patrons of the group of artists who revolutionized the way people see. These men had learned how to view the world in the much same manner as the Greeks and Romans. They even surpassed the ancients, by developing the technology of...
linear perspective. It is therefore not surprising that the Renaissance artist-scholar-scientists (some Renaissance characters were all of these at once), did not try to look forward in time; the conditions of life at that time were not getting any better. Instead they looked backwards—back to the fabled (and largely fictional) Golden Age of the Greeks and the Romans, back to the pre-Christian era of Plato. And no subject captured the Renaissance Imagination more completely than did the alchemical and occult knowledge attributed to the ancient Egyptians. (They never tell us this in school!) Paradoxically, (as we shall see), the search for this wisdom was to be the inspiration for the earliest discoveries of what we call Modern Science.

A review of the effect of occult lore upon the thinkers of the Renaissance, and upon the founders of the Scientific Revolution, can also be found in the first three chapters of *The Reenchantment Of The World*, by historian Morris Berman. In the next chapter we shall learn in just what way magic influenced these men who stumbled like sleepwalkers into a new world of the mind.

**Notes to Chapter One:**

2. *The Survivor*, by Terrence des Pres, Oxford University Press, 1974. The purpose of this book, a study of life in the death camps of Hitler and Stalin, is to ask the question: What are some of the factors, which, in these conditions of ultimate horror, tilt the scales in favor of survival? In the course of his examination of life in the death camps, des Pres concludes that mass extermination is not just an atavistic holdover from the irrational practices of some barbaric, earlier time, (as it was fashionable to think forty years ago), but is rather a result of innate human aggression, amplified by technology.
3. By a “techno-social fix” for a disagreeable situation is meant a technical attempt on the part of some social group to reduce a predicament to a problem.
4. This argument will be found in its elegant, complete form, in the book: *Overskill*, by the engineer and philosopher Eugene Schwartz, Ballantine, 1971, NY. An excellent summary of Schwartz’s ideas, replete with examples, can be located in: *The Arrogance Of Humanism*, by David Ehrenfeld, Oxford Univ. Press, 1981.
5. At the time, climatic changes were making the trees stunted and sparse on the east side of the Rift Valley of Africa.
6. It should be understood that agriculture was not invented overnight, nor in one place. But the recent date for the systematic use of agriculture is approximately 10,000 years ago according to Niles Eldredge of the American Museum of Natural History.
7. Antonio Damasio, *Descartes’ Error*, Avon Books, NY, 1994. Damasio shows that damage to the parts of the brain that help to govern the intensity of emotion produce attention deficiencies, and the inability to perform acts requiring intellectual concentration and persistence. Thus emotion and intellect cannot be separated. You can’t solve a problem unless you have a gut-level desire to do so!
8. As an example of the failure of Modern Civilization to permit us to come to terms with our own pleistocene heritage, here are some disturbing figures. It has been estimated that some ten percent of American adults are clinically depressed, and that 35–45 percent are using some form of medication, (whether over-the-counter, physician-prescribed, street drugs or alcohol) to cope with the symptoms of depression.
(13) Johnson and Earl point out the similarity which existed, after cultural details have been erased, between Medieval France on the one hand, and Japan under the Tokugawa regime on the other, though separated by thousands of miles and five hundred years of time.
(14) Peter Farb, *Humankind*, Houghton Mifflin, Boston, 1978. A number of factors converge to depress the fertility of the hunter-gatherer. Lactating females are unlikely to ovulate while nursing their infants; among foraging peoples nursing continues until the child is in its fourth year of life, and able to walk for long distances. Hence the interval between births is some 48 months in those societies. In the more sedentary farming and pastoral societies that interval drops to between 33 and 36 months. In the Near East, where the domestication of wheat seems to have first occurred, in the interval from 10,000 to 6000 years ago, the population is estimated to have increased from fewer than 100,000 people to more than three million.
(15) *The Lost World of the Kalahari*, by Laurens van der Post; William Morrow & Co., New York, 1958. The author, a gifted writer with a poetic flair, recounts the history of the Bushmen, the aboriginal inhabitants of South Africa, hunter-gatherers who were victims of genocide, and driven out into the Kalahari Desert, where their survivors live today. A truly moving story.
(16) Joseph Tainter, *The Collapse Of Complex Societies*, Cambridge Univ. Press, 1988. Tainter argues persuasively, rigorously, that as societies become increasingly complex, a small group of elite rulers comes into existence, and turn the mechanisms of the society to their exclusive advantage. After this point the chances of collapse grow rapidly. The chief source of collapse seems to be the diminishing marginal utility of each successive increase in complexity.
(18) The fourteenth century, a time of famine, also marked the beginning of mass persecutions: first against lepers, then against Jews, and in time, against witches.
(19) Excellent sources are: *A Distant Mirror*, by Barbara Tuchman; *The Waning of the Middle Ages*, by Jan Huizinga; *Rats, Lice and History*, by Hans Zinsser.
(20) For an excellent treatment of the effects of human meddling upon the European ecosystem see *The Death of Nature*, by Carolyn Merchant.
(21) Demographers have concluded morosely that the rebound of the population more than made up the deficit within less than 350 years.
(22) At one time in the 14th century there had actually been not two, but three claimants to the papal throne (each one excommunicating the other two!).
(23) As early as the end of the 13th century it was possible to discern the appearance of a new outlook, a new kind of personality structure, introspective, and given to personal, private feelings. Dante Alighieri, a Florentine, was able to write in a moment of anguish:

"In the middle of the road of our life
I awoke to find myself in a dark forest
so that the straight path was obscured.."

At the same time, Dante’s fellow Florentine, Giotto, was experimenting with linear perspective, a revolutionary technique which places the viewer at a privileged point outside the painting, so that the viewing subject is separated from the seen object. Thus people were already beginning to “see” in terms of the subject-object dichotomy a century before the unfolding of the Italian Renaissance.
(24) In the 15th century it was common in Western Europe for scholars to read write and speak Latin. Classical Greek was unintelligible in the West before 1453. There is a legend dating back to the early Greeks, that humankind had once experienced a Golden Age. According to the Greek writer Hesiod, during the eighth century BC a golden race of mortals once dwelt upon the earth, “who lived like gods without sorrow of heart, remote and free from toil and grief...They dwelt in ease and peace upon their lands with many good things, rich in flocks and loved by the blessed gods.” According to Hesiod, this desirable state of affairs came to an end when Pandora lifted the lid of her box and allowed the escape of
all the Quasi-Solutions and Residue Problems. The Golden Age was then succeeded by the Silver, Brass and Heroic Ages, each age worse than its predecessor. It is possible to take the view that there is a kind of ‘racial memory’ of time before agriculture, similar to the legend of Adam and Eve.

CHAPTER TWO
WATERSHED

“... and so make ourselves masters and possessors of nature.”
René Descartes.

The story of the rise of what we call the scientific outlook, so characteristic of Modern Civilization, is rooted in a series of fateful events, which took place during the years clustered tightly around the junction of the 16th and 17th centuries. These years have been rightly regarded as a kind of Watershed in time, for it has been said that anyone who lived after the 16th century was unable to understand what had been written before that time. It was the beginning of what we have come to call: The Scientific Revolution.

It was a strange epoch, for it seems as though several different plays were on stage simultaneously, some of them full of storm and fury, each sub-plot interacting with the others, often in ways incomprehensible to the actors, and even to those who fancied themselves to be the directors. It was as if the story were being enacted by a troupe of sleepwalkers. But one of the strangest outcomes of this exercise was a kind of cultural mutation: by the end of the 17th century it was as if a new director had taken over the show, one who had instructed the actors that henceforth an intellectual and emotional distance from Nature was absolutely essential--essential, that is, not merely for the study of the workings of Nature, but for their prediction and control.\(^1\)

Put simply, before the 17th century it had been assumed that the luminaries that grace the heavens are not like the objects we encounter on earth. Therefore, it had been considered useless to attempt to give a faithful description of the paths of the heavenly bodies. By the end of the 17th century such a description, a mathematical one, was now firmly in place. The events that brought about this new state of affairs is called The Scientific Revolution. In later chapters we shall see that this victory for the human intellect was only a temporary one. But we have to understand what was at stake here, and for this understanding it is necessary for us to go "time-traveling," back to the world of Plato, some 2400 years ago.

**Saving The Appearances.** The phrase, dating from the Middle Ages, describes what, at the time, was regarded as the most useful attitude to take towards natural phenomena, and toward the motions of the sun, moon and
planets in particular -- entities whose nature was unknown, and which were in any case regarded as incomprehensible. Thus any recipe, however arbitrary, however outlandish, which enabled humans to predict the positions of these bodies against the backdrop of the stars was considered to be acceptable, because it "Saved The Appearances," i.e., satisfied humans' utilitarian needs. Roughly, the phrase means: "to account for the phenomena."

One of the most important questions in Science is:

“What is it that satisfies our quest for an explanation of any natural phenomenon?”

European Civilization changed dramatically as it passed across the Watershed, and its attitude toward Nature and its standards of acceptability for explanations of such phenomena changed along with it. Prior to the sixteenth century much of the Received Wisdom about Nature, for most educated people, had been derived in a roundabout way, mostly from Plato and Aristotle, who had lived some two thousand years before.

In Plato’s opinion there existed three degrees of knowledge:

(1) Mere observation of Appearances; data-taking being the lowest kind of knowledge.
(2) The union of Pure Knowledge and Observation: Plato called it a kind of bastard activity. The important point is that today one would identify this knowledge with the ability to describe the phenomenon in question by means of a mathematical equation. It is what we now call Science: a marriage of theory and experiment.
(3) Pure Knowledge: the highest kind, the contemplation by pure intelligence of the divine ideas, and of the Supreme Good.

According to Plato, the science of astronomy proper lay fairly within the middle one of the three spheres of knowledge. The Appearances, (that is, the apparent movements of the heavenly bodies, could be watched by observation). The ancient astronomers would devise hypothetical patterns of movement to account for the positions of these luminaries. It was a goal of this procedure, called "Saving The Appearances," to produce a descriptive model, one that could be brought into rough agreement with observation. Thus those who studied the heavens in the years prior to the 17th century did not believe that it was even remotely possible to produce a model that was a completely faithful one. Instead, they were content to Save The Appearances.

As we shall see, there was a vital difference in outlook between the two
years divided by the year 1600; and that difference is the subject of this chapter.

**Copernicus And His Model**

It was a revolution in the science of astronomy that produced the Watershed. This revolution started out innocently enough, but its consequences were profound. In the fifteenth century a peculiar circumstance had forced the Catholic Church\(^3\) to embark upon a program of calendar reform. During the course of the related investigations, scholars consulted ancient texts, particularly a set of tables based upon the book: *The Almagest*, written by Claudius Ptolemy, an Alexandrian Greek, whose motive had been merely to Save The Appearances as they were understood circa 150 AD. To everyone’s surprise\(^4\) the heavenly bodies were found to be not even remotely situated at the places in the sky predicted by the tables of Ptolemy. Consequently a number of superficial attempts were made to produce a “quick fix”; and the most successful attempt was to arise from a totally unexpected quarter. But before revealing the source of this astronomical breakthrough, we first need to establish its historical context, for it led directly to The Scientific Revolution.

In the middle of the fifteenth century, there began the brief period that we have come to regard as the flowering of the Italian Renaissance; the era of Botticelli and Leonardo da Vinci. These artists worked under the patronage of the House of Medici, a family whose members were elected (reluctantly, but apparently in perpetuity) as leaders of the Republic of Florence. The Medicis, who had gotten fabulously rich as a result of their unscrupulous banking activities, were also devoted patrons of classical scholarship and literature. While under the influence of two of the most influential thinkers of his time, Cosimo de’ Medici, the patriarch of the family, became obsessed with two typically Renaissance ideas: (1) that the human character actually partakes of the divine, and (2) that all true philosophy is based upon occult teachings stemming from the ancient Egyptians. These teachings had been transmitted in turn through the Greek colony of Alexandria, whose library had at one time been the repository of all Greek and Egyptian wisdom. The scholars who so influenced Cosimo, were Giovanni Pico della Mirandola and Marsilio Ficino. It was the latter who had mastered the Classical Greek language in order to produce Latin copies of precious texts, which had earlier been rescued from the library of Constantinople\(^5\).

Among these coveted texts were Plato’s Dialogues, as well as the celebrated
treatise on alchemy and occult lore: Corpus Hermeticum, ascribed to the legendary sage of the ancient world, Hermes Trismegistus. When Ficino, appearing before his beloved master, asked: “Signore, which of these texts would you like me to translate first?” Old Cosimo is said to have replied: “I have not many more years left to live, and it would be a pity to die without ever seeing the Corpus Hermeticum.” In the course of his translation Ficino discovered that one of the mystical teachings of the Corpus was that the sun is the true center of The Universe! Now by this time Florence had become the undisputed center of Classical learning in Europe, so it is not surprising to find that during those years young scholars throughout Italy were avidly following the discoveries taking place in Florence; and it just happened that one of these scholars was a young seminarian from Poland, named Nicolaus Copernicus. Copernicus, who was studying in Rome at the time, was clearly fascinated by the heliocentric idea, for in later years he came to write the following words about the solar system⁶:

In the middle of this sits the sun enthroned. In this most beautiful temple could we place this luminary in any better position from which he can illuminate the whole at once? He is rightly called the Lamp, the Mind, the Ruler of the universe. Hermes Trismegistus names him the Visible God.

And so it came about that Copernicus (see picture above)⁷ proposed that it might be possible to predict the behavior of the planets more accurately by assuming (for calculational purposes only, of course), that the sun could be
considered as being lodged in the center of the universe. It is important to remember that at the time, the purpose of any theory was merely to Save The Appearances, to provide a kind of framework upon which to “hang” one’s calculations. In the previous framework, Ptolemy had placed the earth in the center of the Universe, and had originally depicted the moon, sun and planets as traveling about the earth in circular orbits. This crude initial scenario didn’t even begin to Save The Appearances however; and soon it became necessary to add to the original smooth, circular orbits, an exceedingly complicated arrangement of celestial “wheels within wheels”—a kind of cosmic bicycle. Finally, Ptolemy’s model had managed to attain some rough sort of agreement with the crude observations that were possible at his time, and so he had succeeded, for the time, in Saving The Appearances.

Thirteen centuries afterwards, however, when it occurred to Copernicus to try to place the sun in the center of the Universe, his project attracted the interest of the Catholic Church: particularly, of course, the Pontifical Commission On Calendrical Reform. Even the Pope (Leo X, born Giovanni de' Medici, who was an intellectual, and fairly laid-back in matters of religious doctrine), was interested in this new astronomical theory. Discrete overtures were made: “Surely Copernicus would not object to explaining his idea in an audience with His Holiness?” But this young cleric was an extraordinarily cautious person, with an excellent feeling for life in the jungle; he was not about to let himself be put into a possibly damaging position. Therefore, as inconspicuously as possible, Copernicus slipped away back to a comfortable post in his native Poland. And as we shall see, later events were to prove his judgment to have been correct.

Why? For in the year 1517 Martin Luther nailed his 92 theses to the door of the Cathedral at Wittenberg, and the unraveling of the fabric of Medieval Christendom proceeded apace. By the year 1543, at the time Copernicus released for publication his book, entitled: *On The Revolutions of Celestial Bodies*, the theological lines had hardened, and the expression in writing of such heterodox ideas as Copernicus described in the quotation displayed above, would have certainly brought down the wrath of the Church—an institution which had fed and sustained him over his lifetime. This is how it came about that Copernicus, lying safely on his death-bed in 1543, placed his magnum opus in the hands of a friend, a Protestant minister, instructing him to have the book printed—in Germany, the home of the renowned printing presses, and a place where political conditions were sufficiently chaotic to
make it a relatively safe task. Copernicus' book was a time bomb, but it was one with a rather long fuse.

However, the most immediate effect of the invention of movable type (1455) was not the printing of astronomical treatises. Instead, out of the presses had poured thousands of vernacular translations of the Bible, available to anyone who could read them. Printing seemed like a heaven-sent solution to the problem of disseminating information; after all, there has not been another invention to equal its efficiency along that line—until the Web, that is. But it was also a quasi-solution, for it spawned a number of residue problems, one of which is the multiplicity of intolerant Christian sects—a problem that persists to this day. Gutenberg's invention was one of the causes of the Reformation, one of whose more adverse effects began to be felt in France, around the year 1560.

**A Small Question: The Stability Of European Civilization**

In a couple of decades the spirit of the Reformation had spread beyond the borders of Germany, and into France, the most powerful country in Europe, a land where the Roman Inquisition was powerless to interfere. It was not long before a sizeable Protestant community had developed in that country, a development that caused a delicate question to be asked: Given that religion was a powerful component of the public life of a civilized country, could a nation such as France even define itself without forcing all of its inhabitants to be members of one religion?¹³

As a result of religious intolerance, by 1560 France was rapidly spiraling downward into a long, murderous civil war, one that lasted for over thirty years. Although the country had been Catholic (by royal orders) for a thousand years, a sizeable portion of the populace, having developed a kind of allergy to Catholicism, had become Protestants. Arguments had led to name-calling, which had in turn led to a general blood-bath. Finally a fateful decision had to be made. As he lay dying, the last king of the Valois dynasty, a Catholic, named as his successor his cousin, Henri of Navarre, who was a Protestant. The reason? Henri was a born leader. After ten more years of indecisive fighting, Henri, having recently turned Catholic¹⁴, became the newly crowned King of France, and promptly issued an edict of toleration for Protestants. It was the year 1589, and all of Europe was holding its breath.
Would it be possible for things to go on as before? What would become of European Civilization? But wait! We first need to turn our focus eastward, for on 1 January in the year 1600, a strange scenario was being enacted in far-off Prague, capital of the Holy Roman Empire. This scenario was to be a fateful one for the history of the world. And it had to do with the science of astronomy.

**Appearances Saved, Almost Forever, by Johannes Kepler**

During the last years of the 16th century, on an island in the Baltic, a Dane named Tycho Brahe was busily performing measurements upon the positions of the planets, in an attempt to find out whether the Copernican model of the solar system was indeed, as had been alleged, superior to the Ptolemaic, geocentric scheme. Copernicus had, of course, tried to Save The Appearances, but he still insisted that the earth and the planets traveled in circular orbits. This led to an agreement between theory and observation that was sufficiently poor as to make it difficult to choose between the two models. Outraged by a lack of funding, (he was only getting 10% of Denmark's Gross Domestic Product!), Brahe moved, together with all of his equipment, to Prague, then capital of the Holy Roman Empire, to assume the position of Court Astrologer. And, on the first of January of the year 1600 he met his newly-hired assistant, a shabbily-dressed, impoverished young German named Johannes Kepler, whom he immediately set to work observing the positions of the planet Mars, as that body executed its complicated path against the background of the stars—as seen from the earth. In the following year Brahe died, and Kepler, knowing that Brahe’s son-in-law would, in his capacity as Brahe’s legal heir, claim all of his scientific equipment for his inheritance, saw that the time had come to rise above principle. He did what any decent scientist would do: he stole the data outright and promptly fled back to Germany! But it is this matter of the data that brings us to some very interesting questions.

We have seen that Kepler was using Brahe’s observations to determine the orbit of the planet Mars, and that both Ptolemy and Copernicus had followed the ancient Greeks in assuming that the planetary orbits were perfect circles. True, Copernicus' planets, earth included, orbited the sun, while those of Ptolemy orbited the earth. But in neither case could the orbits be regarded as simple circles. Saving The Appearances required that the planets be allowed to move in additional, secondary circles, which ride around on the edges of the primary one, "like planetary gears on that cosmic bicycle." Kepler was at
first determined to fit the data into this model. However, try as he might, he was unable to fit Mars' orbit into any finite arrangement of circles. After seven frustrating years of ineffectual curve fitting, he was forced, in a moment of desperation (inspiration), to model the orbit of Mars with an ellipse. The model worked perfectly, and Kepler was delirious with joy. Something totally new had happened. *The Appearances had been empirically saved by being fitted by a mathematical curve,* and this for the first time in history. Also, for the first time in history the closeness of fit between theory and observation had become a matter of primary importance. But questions then arise: What is the significance of this correspondence? Does there exist a pre-existing, objective Reality to which both theory and observation point? Does this mean that Reality, the world in all its bizarre and intricate symmetry, is inherently knowable to the human mind? Do mathematical concepts *really* map "one-to-one" onto observations? It was a colossal breakthrough. Two thousand five hundred years ago, in ancient Assyria, it had been possible to predict the future positions of the planets with a fair degree of reliability. But there was no theoretical model; there wasn’t really any theory: just a recipe for calculation. What we call the planet Venus, in Assyria was called the goddess Ishtar. Nobody had the faintest notion what Ishtar was doing up there in the sky; the Assyrians just knew how to predict her successive appearances. Nor, for that matter, did Ptolemy or even Copernicus offer any explanation—any rationale for planetary behavior. For up until the seventeenth century, every celestial object, the moon included, was considered to be a perfect lamp, moving on the surface of its own transparent sphere, by Divine appointment. The purpose of these ancient schemes was merely to supply a recipe, what we call today an *algorithm*.17

Thus, the ancient pictures of the world had not been intended as faithful renditions of some kind of objective Reality; they were really metaphors, a manner of speaking, used in order to provide predictions. At this point in history, Kepler chose to deviate from this time-hallowed practice of “Saving The Appearances”, by attempting to represent the appearance of the planets as they would look to an Outsider—a geometer who viewed the entire system as pre-existing--a God's-eye view. For Kepler, and for those who followed in his footsteps for the next 300 years, this metaphor was to be taken as Reality itself. Kepler was looking for Laws of Nature, and to discover them was to discern God’s blueprint for the Universe. Nobody had ever done that before. Here is what the exultant Kepler had to say about his discovery:
“I care not whether my works be read now or by posterity. I can afford to wait a century for readers when God Himself has waited six thousand years for an observer. I triumph. I have stolen the golden secret of the Egyptians. I will divulge my sacred fury.”

As you can see, Kepler was playing for the same high, magical Egyptian stakes as was Copernicus! Far be it from either of these gentlemen to content himself by some low clerical task as merely Saving The Appearances. Obviously Kepler would be satisfied with nothing short of uncovering the magical secrets of the Ancients! His assumptions were at least 2000 years old, dating at least to the time of Pythagoras, and they are as follows:

that the universe is ruled by certain secret numbers, and that these numbers have within them certain magical powers. From this consideration alone, we can see that at the birth of science the magician was certainly the midwife. We will presently encounter another magician, perhaps the last of them: Isaac Newton. But first we must meet the others.

Francis Bacon, "The Man Who Saw Through Time"

In January 1561 he was born to Nicholas Bacon, Lord Keeper to Queen Elizabeth I. During her reign and for some time afterward, a man who sought public office knew that his life could be a disastrously short one, punctuated by a "short sharp shock on a big black block." Nevertheless, Francis Bacon entered public life, and eventually rose to the office of Lord Chancellor of England (the equivalent of our Attorney General) under Elizabeth's Successor, James I. Due to the maneuverings of his enemies, and maybe to his own, Bacon was eventually to forfeit that office in disgrace, and to spend his last years writing books, which he proceeded to launch like ships, upon the ocean of the mind.

It was Bacon The Empiricist who, although he had never once performed a successful scientific experiment, laid the foundations for what we call scientific induction--how we, after having amassed a certain number of facts, can move beyond these, to infer still other facts. Uncannily, it was Bacon who foresaw that science, taken as a social enterprise, would be decisively cumulative in nature: and that in theory at least, there is no limit to the accumulation of scientific knowledge. Further, he saw that it would be
possible (again in theory) to organize a civilization with science as its intellectual center.

One of Bacon's insights arises from his contrasting of science with "natural history":

For even as in the business of life a man's disposition and the secret workings of his mind and affections are better discovered when he is in trouble than at other times; so likewise the secrets of nature reveal themselves more readily under the vexations of art, than when they go their own way.18

--Don't you think that this is an interesting observation coming as they did, from a man who was formerly a prosecuting attorney?

In a later chapter we shall encounter the work of René Descartes, the most influential modern proponent of what is called "rationalism," the notion that reason is a source of knowledge superior to, and independent of sense perceptions. At the opposite pole stood Francis Bacon, the empiricist. What we have inherited from the two of them is a spectrum of attitudes that, taken together, are called ‘rational empiricism,’ and which constitute the Mind of Modern Civilization. In the words of historian Morris Berman:19

The fundamental discovery of the Scientific Revolution ... was that there was no real clash between rationalism and empiricism. The former says that the laws of thought conform to the laws of things; the latter says, always check your thoughts against the data so that you know what thoughts to think.

It is the position taken in this book that the way of the latter, the way of the empiricist is, for me, the safer one, for reasons already given in the previous chapter. I guess it has to do with being a primate.

Galileo, The Last Man Of The Italian Renaissance

By the time Galileo was born in the year 1564 in Pisa, all of the great literary and artistic figures that had made the Florentine city-state famous were dead, and the years of her greatness were largely behind her. When Galileo was in his twenties the center of power on the Italian peninsula had already shifted to Venice, which had become a great naval and commercial power in the Eastern Mediterranean. Therefore it was to the Venetian Republic that he came, for the purpose of working with the great technicians employed at the Venetian
Arsenal. This great Arsenal, sixty acres in area, was the largest military-industrial complex of its time. And it was in its shipyard that war-galleys were built on an assembly line, using oak taken from the forests on the littoral of the Adriatic. It was on Venetian territory in Padua that Galileo constructed his first telescopes. But the telescope had been previously invented in Holland, and Galileo’s most significant contribution was actually what he chose to do with his invention.

One starry night in the summer of the year 1609, Galileo turned his instrument on the heavens. Within a short span of time he was able to observe the craters of the moon, the four principal moons of Jupiter, the rings of Saturn, the phases of Venus and the nature of the Milky Way as an immense wheel of stars. The sight of the four “Medician Moons” cycling conspicuously about the planet Jupiter, quickly convinced Galileo of the correctness of the Copernican Model of the solar system. He soon came to see the moons of Jupiter as a metaphor for the solar system itself, and after this, he never once looked back. And it was his defense of the Copernican Model, coupled with his devastating wit and his love for polemics, that launched Galileo on a collision course with the Roman Inquisition, and to cause the Church to turn out the lights on what was left of the Renaissance.

Galileo’s attitude toward nature can best be summarized by the following quotation from his polemical tract: The Assayer:

> Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the letters in which it is composed. It is written in the language of mathematics, and its characters are triangles, circles and other geometric figures without which it is humanly impossible to understand a single word of it; without these, one wanders about in a dark labyrinth.

It is interesting to study Galileo’s language, his use of metaphor; for him the universe is a book. This choice indicates the power already exercised by the invention of movable type. Further, his book is written in characters are taken from Euclidean geometry, which he invoked as the infallible guarantor of truth.

Again, we find Galileo “laying out the rules by which the game of science is to be played”: 
Now I say that whenever I conceive any material or corporeal substance, I immediately feel the need to think of it as bounded, and having this or that shape; as being large or small in relation to other things, in some specific place at any given time; and as being one in number, or few, or many. From these conditions I cannot separate such a substance by any stretch of my imagination. But that it must be white or red, bitter or sweet, noisy or silent, and of sweet or foul odor, my mind does not feel compelled to bring in as necessary accompaniments. Without the senses as guides, reason or imagination unaided would probably never arrive at qualities like these. Hence I think tastes, odor, colors, and so on are no more than mere names so far as the object in which we place them is concerned, and that they reside only in the consciousness. Hence if the living creatures were removed, all these qualities would be wiped away and annihilated. But since we have imposed upon them special names, distinct from those of the other and real quantities mentioned previously, we wish to believe that they really exist as actually different from those.

From this we can see Galileo as he truly was: a Janus-like character, the last great mind of the Renaissance, but also the first of the New Breed: The reductionists. The contrast between his cast of mind and that of Copernicus and Kepler is dramatic. We do not find him invoking any Egyptian magic, but rather speaking in terms that would have been compatible with the mind-set of any scientist of the nineteenth century.

By restricting himself to studying only those properties of the world that were quantifiable, or could be visualized, Galileo relegated other properties which make up our experience of the world: color, taste, sound or smell, to a lower status of merely subjective mental perceptions. This pattern of selection is an ancient one; we find hints of it in the work of the Greek philosopher, Democritus\(^{22}\) and more strongly in the works of the Roman philosopher Lucretius. We shall encounter these ideas later in our story, for they have proved to be hallmarks of the scientific attitude, and they deserve our most careful attention. Scientists still take pride in the notion that their knowledge is “objective”—independent of the presence of any observer—that it is public knowledge; and further, any knowledge that is not public is held to be not scientific. As the psychiatrist R. D. Laing said\(^{23}\):

> “Out go sight, sound, taste, touch, smell, and along with them has since gone esthetics and ethical sensibility, values, quality, form; all feelings, motives, intentions, soul, consciousness, spirit. Experience as such is cast out of the realm
Galileo’s place atop The Watershed was also well assured by the publication of his last book: *A Dialogue Concerning Two New Sciences*. His manuscript was smuggled from his home near Florence where he was languishing under house arrest, to Holland for publication. In this work Galileo systematically demonstrated that in a frictionless environment, a body moving horizontally continues at constant speed unless subjected to an external force. He then proceeded to demonstrate that a falling body traverses distances that are proportional to the square of the elapsed time. Finally, he recognized that a projectile can be spoken of as undergoing both types of motion, independently, and at the same time; and further, that ideally, its trajectory should be parabolic in shape. As a byproduct, Galileo’s discovery also had the result of refuting Aristotle’s theory of motion; for prior to the time of Galileo it had been received (and infallible) Aristotelian wisdom that a projectile was pushed forward by the rush of air displaced from its front end filling in the vacuum behind it. Eventually, when the projectile starts to fall, according to Aristotle, it is because its proper place is really the ground; for the higher it rises, the greater is the downward attraction. Therefore, in the Aristotelian model the projectile’s path is ramp-shaped, whereas by Galileo’s model the path is a smooth, symmetric curve.

At this point it is useful to ask: Which one of these two models is the more effective at Saving The Appearances? If we want to be able to judge, we need to compare, on the one hand, the Aristotelian model, figure 2-1:
In the above graph we can see that the topmost curve is none other than Galileo’s parabola, reflecting a condition of zero air-resistance. But as we proceed to crank in more and more air resistance, we notice that the downward portions of the trajectory become more and more steep (as the trajectory itself shrinks), until they gradually approach the ramp shape claimed by Aristotle.

What then, can we say about the significance of Galileo’s accomplishment? We will all agree that the path of the projectile is closely approximated in
many cases by a parabola, especially where the projectile velocity is relatively low, and if the projectile presents a streamlined cross-section to the air. But even in the context of an athletic contest we have all observed that a strong head wind produces a tendency for the baseball or football to fall more steeply than it rose, thereby tending to approximate the path described by Aristotle. Still, we can see that Galileo, by considering the problem in its most abstract sense, independently of any context, has gotten hold of a most essential piece of the truth. And it was precisely this kind of treatment, this seductively beautiful method, which Isaac Newton was later to employ with such a devastating effect.

Notes to Chapter 2:
(3) At that time the Catholic Church, ignoring the signs of impending doctrinal disaster, was distracting itself with the problem of calendar reform. For Easter, by definition, falls upon the first Sunday after the first full moon after the Vernal Equinox. But over the centuries the Vernal Equinox, where the path of the sun crosses the celestial equator, had precessed, creeping slowly backwards in calendrical time, and dragging the date of Easter with it, until by late in the 15th century the sun was crossing the celestial equator sometime around 10 March. This meant that Easter was on a collision course with Christmas, (producing a religious catastrophe of incalculable proportions). It was clear to all that the problem had Something to do with astronomy, but nobody knew what that Something was, for nobody in Europe had shown any interest in that subject for a very long time. The most recent attempt to make a systematic scheme of the heavens had been made in around 150 AD by Ptolemy. He had in turn used a scheme invented by Hipparchus, another Greek, who had lived 300 years before him. Hipparchus had become enamored of the idea that the earth could be considered as the center of the universe, and that the sun, the moon, and the stars all revolved around the earth.
(4) During the Dark and Middle Ages the study of astronomy had been assigned a very low priority.
(5) Constantinople, capitol of the great Byzantine Empire, fell to the Turks in 1453, producing a flow of ancient manuscripts into the hands of the Medici.
quote is originally taken from Copernicus’ magnum opus: De Revolutionibus Orbibus Coelestium.
(7) This portrait was identified as a self-portrait by the Polish psychic, Stefan Ossowiecki. See The Secret Vaults Of Time, by Stephan Schwartz, Grosset and Dunlap, NY, 1976. (8) For more detailed information see The Copernican Revolution, Random House, (Vintage, N.Y., 1962), pp 64-73. (9) A visual example of the Ptolemaic Universe can be seen in The Divine Comedy, Inferno, by Dante Aligheri, Dent & Sons, London, 1946. See also The Copernican Revolution, by Thomas Kuhn, Random House (Vintage,) 1962. (10) The Reformation had not yet occurred. His Holiness’ interests centered around collecting books, staging pageants and hunting for pheasants. It can be said without much exaggeration that the subject of religion bored him. (11) Initially there was little or no coherent response from south of the Alps, where the Papacy was in a state of confusion and denial. In Germany the Reformation began gathering momentum like a slow, powerful molasses-like avalanche. Finally after a great deal of bloodshed and confusion, the Catholic Church convened The Council Of Trent in 1545, for the purpose of dealing with what had been initially regarded as an isolated insurrection. Under a thick blanket of censorship, this disastrous convocation dragged on for eighteen years and resulted in the decision to defy the reformers, and use the power of the Roman Inquisition to burn as many of them as possible as heretics. It was like trying to put out a fire with gasoline. And so the Council of Trent launched its Counter-Reformation, which produced a train of religious wars that was to burn for more than 140 years, hastening the decline of religion as a unifying factor in Europe, while at the same time hastening the rise of the nation state. A result of this movement was to give a distinctly nasty polemical flavor to philosophical writings, one that lasted for a long time. (12) As it turned out, the Catholic Church subsequently added his book to its Index Of Forbidden Books. (13) Such a question had been answered in the affirmative by the English 22 years earlier, when Henry VIII had formed the Church of England, making the historic break with Rome, but that tale is well beyond the scope of this discourse. (14) Kings of France were traditionally crowned in the Cathedral at Reims, and the coronation was part of a Roman Catholic religious service. Protestants were thus ineligible to participate. Therefore Henri’s conversion seemed to be
the only way to stop the insane bloodshed.
(15) As the story has it, Tycho perished from a ruptured bladder, sustained as a result of trying to retain his urine while drinking beer at a banquet in honor of a member of the royal entourage.
(16) Until the 17th century it was commonly believed that the sun, the moon, and the planets were not made of the same kind of stuff as was the earth, but rather that these bodies were heavenly lamps.
(17) Much like the Internal Revenue Service’s form 1040.
(20) See: Galileo, Heretic, by Pietro Redondi, Princeton Univ. Press, 1987, for a very sensitive rendition of the story. It must be remembered that Galileo’s appearance before The Inquisition occurred in 1633, when Europe was convulsed by the Thirty Years’ War, an episode which created very strange bedfellows. At that time Pope Urban VIII was endeavoring not appear “soft on Protestantism”, while at the same time working to thwart the Spanish and Austrian cardinals in their efforts to solidify their hegemony over Italy and to isolate Cardinal Richelieu of France, whose government was, to an extent, covertly allied with the Protestants.
(22) Democritus, (460-370 BC), held that there are two sorts of knowledge, one genuine, one bastard. "To the latter belong the all following: sight, hearing, smell, taste and touch. The real is separated from this...".
(25) It was Aristotle who decreed that Nature abhors a vacuum. Thus, according to him the air would rush to the rear of the moving projectile.
(26) Participating Consciousness: the projectile becomes homesick!
CHAPTER THREE
(2012 ed.)

The Plasticity of the Brain
(And what it implies about us)

The lesson we can draw from the history of physics is that as far as we are concerned, 
*what is real is what we regularly talk about.* For better or worse, there is little evidence 
that we have any idea what reality looks like from some absolute point of view. We only 
know what the world looks like from *our* point of view. 
Bruce Gregory

Whenever anybody says: “I am being objective,” that means: “Shut up and do as I say.” 
Umberto Maturana

He who does not imagine in stronger and better lineaments, and in stronger and 
better light than his perishing eye can see, does not imagine at all. 
William Blake

Let’s start with a story....
When I was a child I loved the fairy tales written by the brothers Grimm. These stories 
had been circulating in German culture for hundreds of years, and had been polished to a 
high degree of perfection by generations of women, ‘nannies’ to children of prosperous 
homes. These are not trivial stories, and they have attracted considerable scholarly 
attention¹.

One of them concerns a lovely young woman who wants to marry a handsome prince. In 
order for the marriage to happen the woman must demonstrate her ability to make a 
beautiful gown: (a kind of Ph.D. exam, I guess). To this end, she is locked up in a room 
in the royal palace, together with a supply of flax, a spinning wheel, a loom, scissors, 
needle and thread. In fact, though, she is a beginner, and can’t even weave potholders! 
While she is sitting there, weeping tears of despair, a tiny door opens at the base of one of 
the walls, and three tiny, misshapen old women emerge. Very quickly, one of them spins 
the flax into linen thread while another beams the thread onto the loom and starts to 
weave the thread into cloth. Presently the third woman starts sewing the cloth into a 
gown. At the end of their performance they go back through the little door, and disappear 
from sight.

The final scene is in the Throne Room, where everybody is marveling at the young 
woman’s skill. For some reason that I can’t recall, her act of plagiarism is detected,
producing a very embarrassing situation. But just in the nick of time another little door opens in the wall, and the same little women enter, and march into “center stage,” as it were. One of them, acting as a spokesperson says: “It is we who made that gown! Now look at us, and see how hideously misshapen we have become. My foot has become deformed from the years I have spent operating the treadle on the spinning wheel. My sister’s lips are distended from moistening thread so that it will pass through the eye of a needle. My other sister’s back is deformed from being hunched over the loom. Do you really want a wife who looks the way we do?” Well, of course the prince married the young woman, and they lived happily ever after. Or so we are told….

Three-quarters of a century have elapsed since I read that story, but it has left a lasting impression, as you can tell. There is a lesson to be learned, one that has become part of “folk wisdom.” When we undergo training for any profession, one term for this process is: our “professional formation.” The same term exists in French: “la formation professionelle.” But the French also use the phrase: “la deformation professionelle,” to describe the distortion of our thinking produced in us by our having been trained for a specialty. That’s similar to what occurs with the domestication of animals, isn’t it? A finely trained human is a limited one.

The Sadist and the Monkey
Neurobiologist Gerald Edelman\(^2\) tells of an experiment in which a scientist first studied the brain scan of a monkey, noting which parts of the animal’s brain scan “lit up” as it used its fingers. He next severed one of those fingers, and went on studying what happened to the brain scan with the passage of time. What he found was that the part of the brain that had “belonged” to the now-severed finger was being “captured” by the region of the brain devoted to the other, healthy fingers. Edelman referred to this as “neural Darwinism,” implying that brain cells are objects of competition. For a given neural “route” in the brain, the rule is: “Use it or lose it.” If this is true for the monkey it must also be true for us, and subsequent research has shown this to be the case.

In the years that have intervened since that discovery, battalions of neuroscientists have scanned hundreds of brains, earning a great many doctoral degrees and a gratifying number of promotions as a result. As you might guess, in this manner a great deal has learned about the way humans use their brains. The best introduction to this field is to be found in books written by George Lakoff, Distinguished Professor of Cognitive Science and Linguistics at U.C. Berkeley\(^3\).

Judging from the empirical evidence, we can conclude that the brain enjoys a high degree of plasticity. Also, whatever we normally see, think and do is represented by electrical and chemical signals that travel along neural pathways in the brain. Furthermore, these pathways are strengthened by repeated use, (think: widening a road in order to accommodate increased traffic). For example, it is possible to distinguish an experienced taxi driver from a concert pianist, simply by examining their brain scans.
Any rhetorician or marketing specialist can attest to the effectiveness of keeping messages simple and repeating them endlessly. This last applies strongly in the case of political messages. A political argument phrased to appeal only to the intellect is not nearly as effective as one appealing to the emotions, where the neural pathways are ancient, and have a richer set of neural connections. A regrettable state of affairs, but any rhetorician will tell you that, where arguments are concerned, the solar plexus is a much better target than the cerebral cortex. It is just the way we are built. Our environment places our brains in a continual state of flux, forcing the creation of this sort of neural “wiring and rewiring.” It goes on continually, mostly outside our awareness, so that constant vigilance is our best (and only) defense.

How These Ideas Apply to the Invention of the Phonetic Alphabet
Paleontologists tell us that “modern humans” came on the scene about 60,000 years ago. If this is the case, reading and writing constitute a relatively recent invention, since the earliest alphabets are only about 3400 years old. So, it isn’t reasonable to expect that our ancestors made a grand entrance into prehistory, hard-wired for the alphabet. There is no reason to suppose that evolution even had the alphabet in mind. It does seem more probable that this kind of intellectual revolution required a substantial change in the neural “wiring diagram” of humankind. That is the way that psychologist Julian Jaynes saw the matter. Jaynes consulted ancient texts, and found that they abounded in references to hearing—even when the source of the words was not physically present. This is surprising, but eerie things could conceivably happen when visual information was mostly limited to pictograms until the advent of the alphabet.

Today some of us still inhabit “the Gutenberg Galaxy”; and in males, at least, strings of abstract symbols on the printed page are “displayed” on the occipital cortex of the brain, and then referred to “cataloging librarians” usually “sitting at desks in a region located on the underside of the brain’s left hemisphere. These functions are related to those sites where time sequences are analyzed, and where numerical operations are performed. Here, then, is the site of the kind of thinking that we designate as “left-brained.”

A More Severe Specialization…
Experience seems to be a trackless land; and strings of words, (the noises we make), are like a network of roads that we have superimposed upon that trackless terrain. If this sounds peculiar, we can make an analogy between Experience and Number. We can start exploring the land of Number by filling in the integers, but then the fractions have to be included in the gaps between them, the fractions falling between successive integers. But what about the square root of, say, two, or five? They are neither integers nor fractions. Where do they go? And how about pi, and others like it? Well, a mathematician will tell you that most numbers are completely indescribable. No matter how fine the net we use, almost all of the numbers will squeeze their way to freedom. Good! Now we understand how, in a similar way, language is a kind of road building across our Experience. (If you disagree, just sit down to a computer and try to describe one of your own experiences; it is a matter of very hard work, isn’t it?). Language is simply a form of socialization of
Experience, and also a form of domestication. Further, a phonetic alphabet carries the limitation one step further: It maps the ‘language noises’ we make onto abstract visual symbols. And it is all done in the interest of civilization. But there are still ways that the brain uses in order to get around this limitation, and that is what I want talk about next.

**About Metaphors: How We Really Think.**

What do we mean by a metaphor? **The essence of metaphor is: understanding and experiencing one kind of thing in terms of another.**

Like most people, I had once let myself think of the metaphor as a kind of frivolous ornament, the antithesis to “straight talking and writing.” Hence the phrase: “There’s more truth than poetry in that statement.” But one day I was fortunate enough to purchase a copy of “Metaphors We Live By,” by George Lakoff. His book has made a valuable contribution to linguistics, and Lakoff has also made it possible for us to obtain indispensable insights to make sense of the present disastrous political situation in the United States. Here is a list of just a few of the provocative ideas found in his books.

- **The Embodied Mind:** This means that our normal way of thinking is determined by the way our brains actually work. There exists a very respectable body of data supporting the idea that our way of thinking and talking is heavily mortgaged to our way of sensing and moving. Since Lakoff’s book appeared, it has been discovered that primate brains contain what are called: “mirror neurons.” Among other things, when one monkey sees the fingers of another monkey at work on a computer keyboard, on a brain scan the first monkey’s sensory-motor cortex “lights up.” “Monkey see, monkey do!” (Somebody should try this experiment with hedge-fund CEO’s and other psychopaths). Metaphorically speaking, the beautiful bird of intellect does not sing its own private cage; instead, it must join with other, more ordinary birds of the sensory-motor variety.

- **Thought is mostly unconscious.** Metaphorically, it usually goes on behind our backs. The Germans have a word for our unconscious thoughts: **die Hintergedanken:** (the thoughts behind the ones of which we are aware). Thus, we are mostly not aware of why we think the way we do.

- **Abstract concepts need to be expressed metaphorically, in order to be understandable.**

- **Speaking metaphorically, of course, The Word, spoken or written, by someone who knows how to use it, is pure dynamite.**

- **Finally we need to revisit the ancient question: What is truth? In ‘Philosophy 101’ we are given what is called: The Correspondence Theory, which states that a statement is true if it corresponds to the correct state of affairs in the world. This definition has a built-in problem: There is no Bureau of Standards “out there,” to which we can compare a**
statement, in order to verify its truth. Thus, truth depends upon our understanding of statements. Hence, the definition proffered by Lakoff and Johnson, (which is harmonious with that used by astrophysicist Bruce Gregory in the first epigram at the head of this chapter):

A statement is true in a given situation when our understanding of the statement fits our understanding of the situation closely enough for our purposes.

The Effect of the Invention of Movable Type, Combined With a Phonetic alphabet Upon the History of the World.
That technology could have the power to disintegrate a society should not be surprising. Think of the Industrial Revolution and the disappearance of the cottage industries in England, for example. And think of the effect of the automobile and television on the structure of the city and the family during the 20th century. It would be surprising, therefore, if Gutenberg’s printing press, not only by making new ideas readily available, but by disseminating craft secrets formerly accessible only to members of guilds, didn’t act to dissolve further the ambient social structure. In addition, printing served to undermine the position of the Catholic Church, which had been the supreme authority, for a thousand years, in matters pertaining to faith and morals. Although this was, from one point of view, a very good thing, it cannot be said that it contributed very much to social cohesion. Its effect was a radically centrifugal one, as we shall see. So, it would be astonishing if the printing press didn’t contribute mightily to the eclipse of a society that had already become economically non-viable, thereby hastening the demise of the medieval world.

But a Price had to be Paid For All This: A Loss of Participating Consciousness.

Definition of Participating Consciousness: “The union of the subject and the object in the act of perception.” (Later in this book I shall try to convince you that the universe is not a box of things, but rather a set of observed events.)

Initially this might seem shocking. After all, we have all studied grammar, and have learned that the subject of a sentence is only allowed to be the same as its object in “reflexive sentences,” such as: “I am fooling myself.” In all other cases ‘who’ is supposed to be distinct from ‘whom.’ When the dog bites the man, there is no grammatical possibility of confusing the two. But when we are forced by circumstance to resort to the use of a metaphor, so that our hearer may “grasp us squarely,” we then find ourselves “moving into new territory.” We are talking in a manner removed from a brute statement of fact, while using words that still unite that fact to us. It is seeing one thing in terms of another that dissolves multiplicity, restoring unity. As James Joyce once said: “Any object, intensely regarded, may be a gate of access to the incorruptible eon of the gods.”
Here is just one example of the use of a metaphor, but I assure you that there exist hundreds of them. *Argument is war.*

Your claims are indefensible.
He attacked every weak point in my argument.
His criticisms were right on target.
I demolished his argument.
I’ve never won an argument from him.
If you use that strategy, he’ll wipe you out.
He shot down all my arguments.

In England, by the latter part of the seventeenth century, the metaphor had come under fire from the ruling classes, who associated it with “enthusiasm” (read: altered states of consciousness). There had been a recent civil war, together with a thriving counterculture, but the propertied classes and royalty were once more in the saddle. For them: “The poet is always in the devil’s camp.” Thomas Sprat, Secretary of the Royal Society, was one of the leaders in an effort to re-structure the English language so as to eliminate the “dreaded metaphor.” Another member of this faction was a certain Samuel Parker, who wrote in the following fashion:

> All those theories in philosophy which are expressed only in metaphysical Terms are not real Truths, but the meer products of imagination, dress’d up (like Childrens babies) in a few spangled empty words.... Thus their wanton and luxuriant fancies climbing up into the Bed of Reason, do not only defile it by unchaste and illegitimate Embraces, but instead of real conceptions and notices of things, impregnate the mind with nothing but Ayerie and Subventaneous Phantasms.

Like the rest of us, Parker couldn’t avoid using metaphors to save his soul.

In her treatise: “*The Rise of Magic in Early Medieval Europe,*” Valerie Flint describes the efforts of the Roman Catholic Church to stamp out magical beliefs in the minds of the inhabitants of Western Europe during the period between the fall of Rome in 476AD, to the end of the tenth century, the period commonly called “the dark ages.” At the outset the “natives” were thoroughgoing animists; everything in their environment was alive, and filled with spirits, benevolent or otherwise. Sorcery was an uncomfortably common practice. But against all this, the Church found itself helpless; the “natives,” the country folk, remained obdurately animists—that is, they believed that everything is in some sense, alive, and pregnant with meaning.

What were the priests to do? The Inquisition, with its methods, had not yet been invented—these would have been impractical in any case, for at the time the bishops were heavily outnumbered. The problem was solved, after a fashion, by “priest-craft” – acts of resourceful bishops, who would build Christian churches upon sites of former pagan shrines. The medieval Church did not permit priests to perform cures, but simple
monks (those who had merely taken vows) in monasteries were free to cure by acts of “white magic” according to their talents—and that is just what they did. It was necessary in order to compete with the native shamans. In this manner was born “Christendom,” in which one form of magic was superimposed upon another: producing a “state of mind” that lasted throughout Europe for a thousand years. And the embers of that fire are still warm—in some places.

Now that we live in “the digital age,” in which our hallucinations are only “electronic ones,” we might ask: What ever happened to Magic--to sorcery? My answer is that from the scattered bits of evidence available, it is still “there.” In England, until after World War Two there was a law in force against the crime of “witchcraft.” Furthermore, I once read a doctoral dissertation in ethnology by a certain Dominique Camus who, for his graduate project, had spent six years studying healers in Brittany. His research project took a fateful turn when it became clear that many of the healings were being done in order to counteract the effects of spells that had previously been placed upon people by sorcerers. Shunned by his colleagues and, ultimately by his own family, he persisted in reporting his discoveries in an empirical way, avoiding “rationalistic” value judgments.

So, what brings about this unwillingness to face the fact that sorcery exists? The answer to this question may also be one of the answers to why witchcraft was so energetically persecuted from the 14th to the 18th century. For whether or not these practices are truly efficacious, they manage to produce an atmosphere of hatred, fear and demoralization, corroding the social bonds that link people with each other. It is best to avoid sorcery!

To make my case that Participating Consciousness is alive and well, even in the sacred precincts of NASA, you might want to know that, as the scientists and engineers awaited a critical moment for their recent 2012 Mars Rover mission, they performed a curious ritual: They shared cans of peanuts. According to one scientist: “Missions always seemed to work out better when we had the peanuts there.”

What do I conclude from all of this? The reader is of course, free to think as she/he likes. But, as in the movie The Wizard of Oz: “We are not in Kansas any more.” As a matter of fact, we were never really in Kansas in the first place; we just refused to admit it. It was a Kansas of our own devising. More about this in a later chapter.

Notes to Chapter Three:

(1) See: ‘The Flight of the Wild Gander’ by Joseph Campbell, for a wonderful discussion about the Grimm brothers, how they accumulated the Tales, and about the surprising origins of some of the famous sagas. The Grimm stories, more than 200 in all, are listed by title, beginning on page 187.
(3) See endnote (7).
(4) See: *The Origin of Consciousness in the Breakdown of the Bicameral Mind*, by Julian Jaynes. There is room for criticism here; Jaynes used the word Consciousness as though it is readily definable. It tends to get confused with “awareness.” And then there is the question of “how we are aware of being aware.” It is like a hall of mirrors. It is also self-referent. See Douglas Hofstadter’s book: *Goedel, Escher and Bach*, for more fascinating stuff.

(5) Brain-lateralization tends to get over-emphasized. It’s more complicated than being left-or-right-handed. See Wikipedia. One of the problems with this is that researchers like Broca, Wernicke and Sperry seemed to work with people who required surgical intervention.


(7) See: *Metaphors We Live By*, and *Philosophy in the Flesh*, by George Lakoff and Mark Johnson. You can Google George, and in doing so, you will hit an intellectual gold mine. The empirical bases for his work are the recent discoveries that have been made in the field of cognitive neuroscience. His analysis of “framing” has contributed a great deal to our understanding of why we make such irrational political choices. He has written many books, and all of them are good. Advance token to Bookstore and BUY!

(8) This could be a long endnote! The City of Detroit owed its vitality to the automobile industry; until the latter brought about the freeway system. This in turn carved up entire neighborhoods with freeways, finally leading to the exodus of a large fraction of the population. The driving force behind this was, of course, racism. As far as television goes, I believe that few inventions have contributed as much to alienating people from each other. I recommend the book: *Amusing Ourselves to Death*, by Neil Postman.

(9) *The Rise of Magic in Early Medieval Europe*, by Valerie J. Flint, Princeton University Press,

(10) The famed cathedral: Notre Dame de Chartres was superposed on a Druid temple, whose remains are still detectable in the crypt of that building. I’ve been there.

CHAPTER FOUR
THE WORLD BEYOND THE PICTURE FRAME

There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy.
Hamlet, Act I Scene V.

It is venturesome to think that a coordination of words (philosophies are nothing more than that) can resemble the universe very much.
Jorge Luis Borges: Labyrinths

In the previous chapter we discussed certain events that took place during the period centered about the year 1600--events which turned out to be the opening guns in the Scientific Revolution. However, as a description of the Human Experience peculiar to that time, our story remains incomplete, for it lacks a vital ingredient. By way of analogy, consider a history of that same era, written a hundred years later, during the 18th century. It would have been a chronicle of popes and kings, and their battles, with an occasional genuflection to great literary works of the past, such as those of a Shakespeare or a Milton. History, then, is a matter of taste, a tale about what someone considered to be important. And the power structure of a civilization is always the principal patron of the historians, and therefore also the arbiter of taste. Since such an arrangement is, figuratively speaking, somewhat anaerobic, it might be useful to "challenge the dominant paradigm," thereby letting in some fresh air.

Included in the following pages, are three instances of human experience that are clearly discordant with The Myth of Modern Civilization. There is no reason to believe that all of these testimonies were necessarily falsehoods. But first, in order to understand the background for these stories, we need to examine the events that took place in Italy as a result of the Protestant Reformation, which had begun in the year 1517. It was not until the year 1545 that the Catholic Church, finally realizing the seriousness of the Protestant challenge, convened a General Council in the city of Trento, in Northern Italy. The Council of Trent, as it was called, lasted until 1563, and resulted in a poorly considered decision: namely to circle the metaphoric wagons, and fight with every available resource. The Church's arsenal included the Roman Inquisition, with its time-tested final argument: torture of heretics by means of "waterboarding", followed, whenever necessary, by burning at the stake. While conducting their interrogations the inquisitors had been instructed to take careful notes of all the proceedings, in order to ensure that no one would be executed by mistake, and that the entire sadistic procedure would be carried out in a manner in accord with the very highest standards of professionalism. These records were duly filed away in the archives, and subsequently forgotten, until around the year 1960 when some of them were placed in the hands of the historian Carlo Ginzburg. The stories should be read now, before going any further into the chapter, for they are fascinating, and their implications are immense.

The Benandanti: What Were They Doing?

By their own testimony, at night the Benandanti (those who walk well) were traveling in a kind of spirit world, doing battle with witches and goblins, and curing the sick--for the sake of their neighbors, members of their community. This experience may have really been the product of deranged minds, but
remember: there were scores of them. So, is it really explaining anything to dismiss this phenomenon as a kind of folie à plusieurs?

**First Story:** It is March 21 1575 (Galileo was 9 years old). We are at the monastery of San Francesco di Cividale, in that mountainous region of Northern Italy known as Friuli, where Slavic, German and Latin cultures meet. It was at that time that the astonished inquisitors learned about the existence of a peasant named Paolo Gasparutto, who claimed that he could cure bewitched people; he also claimed that he roamed about at night with witches and goblins. In addition, he claimed to be “one of those who walk well”, *I benandanti*, and that at the four seasons of the year his troop of *benandanti* would go in spirit to do battle with the witches, for the purpose of securing the fertility of the fields.

So who were these, *I benandanti*? They were those who were born with a caul over their faces, who fell into a trance or a deep sleep on certain nights of the year. At such times they “journeyed,” and later they remembered--remembered traveling on the backs of cats or dogs, armed with fennel sticks against the witches, fighting for the fertility of the crops and the harvest.

The Church officials interrogated these peasants mercilessly, trying to bend their testimony until it agreed with categories with which they felt more doctrinally comfortable, (such as sorcery, Witches’ Sabbaths and copulations with Satan—the routine, day-to-day humdrum stuff of Christian diabolism), but all to no avail. Revelations of the kind supplied by Gasparutto multiplied, and for a hundred years the Inquisition exerted all its powers on the *benandanti*, to get the kind of confessions that sat conformably upon the convolutions of the ecclesiastical mind. However, many of the *benandanti* held out to the bitter end, and it is their testimony that has come down to us.

**Second Story:** In 1692 (Newton was 50 years old at the time, and his *Principia* had been already published), an eighty-year-old man named Thiess in Jürgensburg (in what is now Latvia), confessed to the judges interrogating him, that he was indeed a werewolf! Three times a year, at night, he and his fellow werewolves would fight, armed with iron whips, with the devil and with sorcerers. What was at stake? Again it was the fertility of the fields.

**Third Story:** At the end of the 14th century two women of Milan confessed to having experienced episodes of “night-flying” while in a state of ecstasy. It seems that they had been having periodic meetings with a certain mysterious lady, whom they called *Donna Oriente*, who was always surrounded by a troop of animal attendants. And again, in 1457, the learned bishop, Nicolas of Cusa, sermonized against two old women of Val di Fassa, who confessed to having been visited by *una bona domina*, whom they referred to by the name of *Richella*. They had touched her hands, which turned out to be covered with hair, and in turn she had stroked their cheeks with those hairy hands. To the bishop, they were merely witches, linked with The Evil One.

**How Can We Interpret These Stories?**

It would appear as though we are confronted with the collision of three disjointed World Views, probably arising from the invention of the phonetic alphabet—views to which we need to give the labels: Type One: The Scholars, those who had access to printed books; The world of Type One, that of Kepler, Galileo, and later of Newton, could not even have existed without the invention of the printing press.

Type Two: The Priests and Bishops, who tried to mold the testimony of the peasants to fit their own peculiar cosmology (i.e., the Devil, diabolical possession, the Devil’s Sabbath, etc.). The theology of the Roman Church, although purportedly a transmission of the inspirations of the early patriarchs, is still, as
we have pointed out, a corpus that had been originally set down by hand, in writing.

Type Three: The people of the non-literate world, who depended upon the existence of a living oral tradition. But in compensation for this lack, they remained more intuitive, and more in contact with the workings of the Unconscious Mind. The Type Three World was effectively a medieval one, at least half-pagan--even in Italy, the heartland of Roman Catholicism.

But the position we are taking in this book is this: We shall try to to be fair-minded, rigorously empirical. Thus we cannot dismiss a consistent body of testimony out of hand, solely on “rationalistic” grounds— you can’t prove it false, “by actual conjecture.” That would cause the discussion to degenerate into “Argument From Theory.” The criterion for a good argument is that it must be based on Observed Facts. Only these can be said to constitute a body of data. Arguments based only upon theory are as sand castles on the beach.

Two things are impressive here. The first is the fact that dozens of these benandanti, over a period of a century, confronted by the intimidating power of the Roman Inquisition, stuck to their story. This is also quite surprising, since it is well known to experts on “enhanced interrogation” that, when confronted with a threat of torture or death, any normal person will tell his/her tormenter whatever cock-and-bull story he wants to hear. The second thing concerns a certain thread, one that unites the three stories into a grander framework, one that is internally consistent, but also totally inexplicable in modern terms. I was so astonished that I couldn’t resist the temptation to tell you about it. So here is the question:

What was it that these three stories had in common? Answer: In all three cases the protagonists, in some unknown manner, journeyed. Not as you or I would travel, not in the flesh, that is, but rather during what you might call an out-of-body experience.

Also, (1) They fall into Altered States of Consciousness, (2) They “journey” to The Other Side, the Beyond, and (3) While in an altered state, they perform feats for the benefit of their community.

All of this connects to a very ancient practice: that of Shamanism, a practice that dates back at least to Upper Paleolithic times, some 40,000 years ago. Strangely, the practices of the Benandanti are remarkably similar to those of indigenous people in the world, whose lives have been documented tirelessly by ethnographers and anthropologists for the past two centuries and more. Further, shamanism still persists today in various nooks and crannies of the world; where it still displays considerable vitality. The question is: how on earth did these Italian peasants come to know about it? Had the tradition really come down them from Paleolithic times, by word of mouth? And why did Gasparutto's experience bear a strange resemblance to that of Thiess, in faraway Latvia? Was this perhaps an example of the kind of racial memory called the Collective Unconscious? Was Carl Jung really correct in intuiting the existence of the Collective Unconscious, most accessible to those who are in an Altered State?

And in the case of the peasant women of Val di Fassa, what is the significance of Richella, la Bona Donna, she of the hairy face and skin, surrounded by an entourage of animals? Once again we find that the thread leads into the distant past, into the same Upper Paleolithic era. In shamanic experience the Mistress/Master of the Animals is understood to be the personage with whom the shaman intercedes on the behalf of the tribe, in the hope of bringing about a plentiful supply of game. In Greek mythology this personage, the Mistress of the Animals is identified with the goddess Artemis, an immensely powerful pre-Olympian deity, a variation on the theme of The Great Goddess, symbolized by a she-bear who emerges from hibernation on the second day of February. In Roman mythology Artemis was "civilized"
to represent “The Chaste Diana”, the goddess of the hunt—a pallid substitute for the Greek Artemis, who was, of course, The Real Thing. Are we really supposed to believe that the women made up that story, one that, just by coincidence, happens to be in agreement with information discovered by mythologists and archaeologists during the past century?

**A Brief Introduction To Shamanism.**

Before Civilization, (i.e., before organized religion), there was shamanism, an essential element of tribal culture. Shamanism is not a formal belief system—not in the sense that the sects of Christianity constitute rigid belief systems. It has neither doctrines nor hierarchies. Rather, it is based upon experience; it is essentially *empirical*. Its essential points can be set down in a very few sentences.

Here they are:

1. The shaman is a person who has developed the power to "journey" from ordinary reality to shamanic reality, a form of reality accessible only to those in an altered state of consciousness.
2. He/she does this for the good of the community. It is not a parlor trick.
3. Upon returning from shamanic reality he/she brings back needed information, or returns with the power to cure sickness in one or more members of the community. As long as humans lived and hunted in groups, at least one of the members of the group would be required to fill the role of the shaman: to be able to find game and to cure illnesses. From this consideration it seems probable that the practice of shamanism is at least 40,000 years old.
4. Related to this is the hypothesis that, in some sense, whatever is, is alive. This is called panpsychism. Central to this notion, is the fact that life is not merely a property of individuals; instead, it is a vast process, of which we are merely a tiny part. That is an extension of Gary Snyder's observation in Chapter One of this book.

Ethnologists and anthropologists have studied shamanic practices for over two centuries, although they usually worked from within the belief system of Modern Civilization. One of the most noteworthy, as well as sympathetic, of these investigators was Knut Rasmussen, who worked in the Arctic with the Inuit during the first third of the 20th century. Another researcher who did valuable work among the Australian aborigines was A. P. Elkin, whose book, *Aboriginal Men Of High Degree*, has become a classic. (Indeed, there are interesting similarities between the process by which an aboriginal Australian becomes a shaman and the modern process of Ph.D. candidature). An extensive bibliography on shamanism can be found in the book, *Dreamtime and Inner Space*, by Holger Kalweit. But it remained for a religious scholar, Mircea Eliade, to point out the curious fact that essential "core shamanism" is much the same, all the world over. Initially, Eliade's discovery was not received with much enthusiasm by the anthropological profession; for, in addition to the natural antipathy between the "splitters" and the "lumpers," Eliade was a religious scholar, and not a professional anthropologist. As nearly as I can tell, there seem to be two possible interpretations of the fact of shamanism's universality: either it is of such ancient provenance that it had its beginnings at a time when the entire human race lived in a small area of the world, or that, (much more likely), access to non-ordinary reality happens to be an innate human characteristic, just as musical ability is. The most recent research developments seem to support this point of view. It is this last alternative that makes shamanism, and its corollary: panpsychism, central to our program of exploration.

**How The Shaman Reaches An Altered State. The Technique Of Ecstasy.**

It goes almost without saying that no two humans have the same abilities, and the attainment of altered states is no exception. These aptitudes seem to follow the well-known normal distribution curve. Some individuals can attain such states at will, indicating that the wall between ordinary humdrum reality and
the altered state is, for them, a thin one. For other individuals (sometimes called "hard-heads"), the task is well-nigh impossible—I suspect that it is all a matter of neural connections. But average individuals seem able to attain altered states by means of various tools and methods, the most common of which is the drum, which is the trademark of the shaman. Steady, rapid drumming, at a rate of about three or four beats per second, continued for a period of 20 minutes, can produce a trance state in a large fraction of the population. Other effective procedures include rubbing the edges of Tibetan bowls, plucking bowstrings, staring at candle flames, chanting, dancing—to exhaustion. Of course, if more heroic methods are required, there are certain psychoactive substances that may be used, (all the while, of course, paying meticulous attention to the "set" and the “setting”).

The Shamanic Cosmos: Really the Stuff Of Myth.
Non-ordinary Reality, as experienced by the shaman, appears to have a kind of structure: its "cartography" comprises a Middle-World, (that of ordinary reality), a Lower-World, where the shaman could encounter a "power animal," and an Upper-World, where one might meet a "spirit guide." It is the shaman's duty to assist the members of his/her community; it is to this end that the shaman possesses his/her powers. We are not playing parlor games here. Since shamanism provides a world-view as well as a description of how the shaman is to function as an actor, then what we are studying is the stuff of Mythology--a Myth that far pre-dates history.

Participating vs. Non-Participating Consciousness: A Practical Example.

In the previous chapter we referred briefly to the concept of Participating Consciousness; it is here that I shall try to convince you of its usefulness. There is a conceit peculiar to the social sciences, that it is important to emulate the methods employed by the physicist or chemist, an attitude sometimes called "physics envy". A central feature of this program is the assumption that it is always desirable, or possible, to separate the experimenter from the object of his/her manipulations. Sometimes this experimental goal is referred to as the subject-object distinction, or as "objectivity;" but another term for it is "non-participation." Thus the truly "scientific" anthropologist will try to treat the objects of his/her study as if they constituted some kind of bacterium viewed under a microscope. This practice, when upheld, has made social science writing the world's standard for unremitting dullness. Fortunately, there have been some anthropologists who have disobeyed this commandment, and have eaten the forbidden fruit, committing the sin of "participation" with those whom they have studied.

One of the most famous of the transgressors was Frank Hamilton Cushing, who in the year 1879 was sent out by the Smithsonian Institution as a member of a group of ethnologists, to New Mexico, to study the Zuñi. With time Cushing came to love and respect the Zuñi; and as his understanding of them increased, his regard for the U.S. government decreased proportionately. Not only was Cushing inducted into the tribe, but he was also made War Chief and Bow Priest. And his fellow ethnologists? They all deserted him. Finally, when word of his activities reached Washington, Congressional pressure was subsequently applied to return Cushing to the humdrum world of the white man. One thing is certain, however. If he had remained faithful to the commands of scientific objectivity, he would never have learned as much about the Zuñi as he otherwise did. The only way to understand what it is like to
Be a Zuñi is actually to become one, to attain Participating Consciousness. In the following sections we discuss two instances in which Participating Consciousness was attained by scientific investigators, almost against their wills.

"To Understand Us You Have To Take Our Medicine": How An Anthropology Student Became A Shaman.

In the late 1950’s, Michael Harner, then a graduate student at the University of California at Berkeley, lived among the Conibo Indians in the Ucayali Valley in the Peruvian Amazon. His research on their culture was going fairly well, but their responses to his questions about their spiritual beliefs were vague to the point of being evasive. Finally they told him that if he really wished to learn, he would have to take the shamans’ sacred drink, a variant of ayahuasca, the "vine of the soul;" further, they warned him that the experience would probably be a frightening one. As a western-trained graduate student, his first instinct was to decline; but then he asked himself: "Do I really want to learn about these people, or not?" Whereupon he mustered up his courage and agreed, with some misgivings, to “take the medicine.”

It is impossible for me to do justice to Harner's experience in these pages; instead, it is necessary for you to read his own account, one that has by now become a classic. From that point on, Harner began a study of shamanism, and although he later held faculty positions at Columbia, Yale, Berkeley, and The New School for Social Research, his life's calling was to be a shaman! For more than 30 years, he and his associates have given workshops all over the world, and his CDs of drumming and other techniques are readily available.

Harner's study of shamanism convinced him that it is not necessary to use entheogens such as ayahuasca in order to attain the shamanic state of consciousness; there are other methods that can produce the same results. It was he who almost single-handedly created a renewed interest in techniques of shamanic drumming. But what seems to me to be the most striking result of Harner's research, is that it appears to be possible, even in the midst of urban civilization, for one to "journey," in what is apparently the same manner as our paleolithic ancestors, to break the bonds of ordinary reality, and apparently to transcend space and time. This is not a doctrine; it is an empirically verifiable observation (in most cases, and with practice). Therefore it cannot be rejected out of hand, merely because it happens to be inconsistent with the theories appearing in The Great Myth, (and therefore held to be a priori impossible). Moreover, it should be a source of consolation for us to be able to speculate that after the inevitable collapse of Modern Civilization, the survivors will return gratefully to the practice of shamanism.

Stanislav Grof, Transpersonal Pioneer.

In his teens Stanislav Grof had dreamed of a career as a creator of animated cartoons, but on the night of his high school graduation he happened to open a book given to him by a friend: it was Freud's famous: Introductory Lectures In Psychoanalysis. This event became a turning point in his life, for young Grof, fascinated, sat up all night reading it, and immediately resolved to become a Freudian psychoanalyst. In due time, he completed his medical studies and psychoanalytic training in Prague, and began work at a clinic there. However, doctrinal problems connected with the Communist takeover of Czechoslovakia caused the doctors at his clinic to abandon the Freudian “talking cure” and to experiment instead with psychoactive substances. On one fateful day in the 1950’s a certain package arrived from Sandoz, Ltd., of Basel, Switzerland, containing ampoules of LSD-25, a semi-synthetic substance that had been discovered by the Chemist Albert Hofmann in 1943. At that time LSD had been termed a
"psychotomimetic" drug, meaning that its apparent function was to produce temporary psychosis. Therefore, the doctors at Grof's clinic began to take the drug themselves, to be able to "visit" psychotic states without becoming permanent residents: “temporary nut cases.” In this way they hoped to gain a better understanding of their patients. For Grof, however, one dose was all that was necessary for convince him that, when administered in the proper clinical setting, LSD would be able do for the mind, (in his words), what the telescope has done for astronomy, and what the microscope has done for biology. Beginning in Czechoslovakia, and later in the United States, by which time his briefcase was bulging with 5,000 experimental protocols, Grof was able to verify his earlier discovery, and had used LSD in conjunction with psychotherapy to produce spectacular results with patients whose problems had previously been intractable. But a storm was already brewing.

The history of the use of LSD during the 50's and 60's is a fascinating one, which I shall summarize here. This compound had been of intense interest to the CIA, the U.S. army and other unsavory types, who experimented briefly with it, hoping that they could turn it to some useful purpose, such as “mind control.” However, these efforts were abandoned when it was discovered that, instead of being the ultimate brain-washer, LSD functioned in quite the opposite way, de-conditioning those to whom it had been administered. (One of former my students described it as “the ultimate bull-shit detector”). In the early 60's at Harvard, Timothy Leary and his associates experimented extensively with LSD and other substances; and by a peculiar synergism, the use of entheogens became a kind of badge of honor for those who opposed this nation's imbecilic involvement in the Vietnam War. Members of Congress, fearing that their government was being effectively de-legitimized by an army of stoned youngsters, panicked, placing a ban on all the psychoactive substances whose names they could spell, designating them oxymoronically as "controlled substances." It should come as no surprise that psychotropic drugs, far from being "controlled," remained easily obtainable on the street, but the results upon those engaged in doing serious scientific research were nothing short of disastrous; for in this sector the ban was totally effective. It even became dangerous to one’s career to have ever been associated with research with “psychedelics”. Under the effects of LSD, or of Holotropic Breathwork, Grof's patients have apparently been able to gain access to psychological material that is, to say the least, paradoxical, at least when viewed by the rest of us when we are in the hyletropic state. The experiences encountered seem to transcend space and time. Grof breaks those experiences down into three categories. They are:

1. Transcendence of the usual spatial barriers. Such experiences include merging with another person into a state that can be called "dual unity"; assuming the identity of another person; indentifying with the consciousness of an entire group of people. One can even seem to merge with the consciousness of the entire planet.
2. The overcoming of temporal boundaries--the transcendence of linear time; apparently having experiences from past lives.
3. Access to archetypal dimensions; deities and demons of various cultures.

According to Grof, on occasion, some of the experiencers of the holotropic state even return to the
"normal world" with information that is verifiable, although they could not have obtained it by "normal" means. After forty years spent in this field of exploration, Grof is enthusiastic about the value of altered states. He says:

Moreover, it has become obvious that human beings have a profound need for transpersonal experiences and for states in which they transcend their individual identities to feel their place in a larger whole that is timeless. This spiritual craving seems to be more basic and compelling than the sexual drive, and if it is not satisfied it can result in serious psychological disturbances.

It is readily apparent that the experiences described in the above paragraphs, (and in the references), are totally incompatible with the theories derived from the accepted mythology of Modern Civilization. An orthodox believer in the Myth would object on two grounds. First, there is the problem of incompatibility with "theory"—that it doesn't fit the Story Line. Second, a tradition (often a valuable one) has sprung up, which holds that no effect can be considered "real" unless it is readily repeatable, (by anybody) and can be verified under strict laboratory conditions, paying strict attention to "objectivity." It is an unspoken, (and unexamined), assumption among the orthodox that every "real" phenomenon in the universe will always conform to this condition. However, this assumption runs counter to the experience of most people.

**In What Sense Can We Say That All This Is Real?**

For the present I would like to sidestep this issue, until later. But a case can be made for the notion that reality is a kind of construct. I shall present two quotes touching on this question, both by eminent thinkers.

The first is by the distinguished French scholar Henry Corbin, who devoted a lifetime to the study of Islamic mysticism. In his book *Mundus Imaginalis*, he makes the following argument:

…it must be understood that the world into which [these visionaries] probed is perfectly real. Its reality is more irrefutable and more coherent than that of the empirical world where reality is perceived by the senses. Upon returning, the beholders of this world are perfectly aware of having been “elsewhere;” they are not mere schizophrenics. This world is hidden behind the very act of sense perception and has to be sought underneath its apparent objective certainty. For this reason we definitely cannot qualify it as being imaginary in the current sense of the word, i.e., unreal or non-existent. [The imaginal] world…is ontologically as real as the world of the senses and that of the intellect…. We must be careful not to confuse it with the imagination identified by so-called modern man with “fantasy.”

The second author is the great psychologist and philosopher William James, who wrote:

"..our normal waking consciousness, rational consciousness as we call it, is but one special type of consciousness, whilst all about it, parted from it by the filmiest of screens, there lie potential forms of consciousness entirely different. We may go through life without suspecting their existence; but apply the requisite stimulus, and at a touch they are there in all their completeness, definite types of mentality which probably somewhere have their field of application and adaptation. No account of
the universe in its totality can be final which leaves these other forms of consciousness quite disregarded. How to regard them is the question—for they are so discontinuous with ordinary consciousness. Yet they may determine attitudes though they cannot furnish formulas, and open a region though they fail to give a map. At any rate they forbid a premature closing of our accounts with reality."


In Book X of *The Republic*, Socrates states his position that the work of poets and dramatists, and of painters too, appeals to the baser, more emotional parts of our minds. He goes on to say that the arts have a morally corrupting effect even on the best sorts of people. When we watch a play, pity and sympathy arouse strong feelings in us, causing us to be swept away by our emotions, and lose our self-control. Socrates believed, (if we can believe Plato), that moral guidance can come only from the kind of knowledge reached by reason. In a sense, *The Republic* represents the first of the Utopias, an attempt to create the ideal State, (an authoritarian one). The point is that Plato seems to have recognized that there was no place in his rational State for individual epiphanies or for ecstasy. Foregoing these experiences seems to be an "initiation fee" to gain entrance to this ephemeral thing called Civilization. Perhaps this is the key to the riddle: Why do people shrink from the possibility of re-enchanting the world? Is it because of the danger of finding empty shelves at the supermarket?

Notes to Chapter Four:
2 Caul: the inner fetal membrane of higher vertebrates, esp. when covering the head at birth, (Merriam-Webster). Traditionally there is something uncanny about this. It is an item of folk-wisdom, that people born with caulns have "second-sight", i.e., they are psychic. Journeying is a word that describes a central feature of shamanism. See Harner, Michael, *The Way Of The Shaman*, 2nd ed. 1990.
3 Val di Fassa is located in the mountains of Northern Italy, the foothills of the Alps. In colloquial Italian, *Una bona dominina* means: "a good lady”. Her hands, covered with hair, call to mind the fact that the Greek goddess Artemis appeared in the form of a bear.
4 Before the work of Ginzburg, the principal modern historians who had concerned themselves with what has been regarded as witchcraft, have usually been people like Hugh Trevor-Roper and Keith Thomas. These gentlemen managed to avert their attention from the reality of what these people experienced, cautiously confining themselves to the treatments accorded the suspected witches. The reason given for this curious omission was that, for them, the witches were obviously psychotic, and that it made no sense to try to enter their mental universe. For the rationalist mind the hidden world of the indigenous peoples lies beyond a locked door. Nocturnal journeying? Surely **my** ancestors would never do a thing like that!
5 Master/Mistress of the Animals, a deity of the Hunter-Gatherers. An example is Pan, a figure of great antiquity, with horns upon his head, and cloven hooves, playing his pipes. It is the animals who are listening to him. Carlo Ginzburg *Ecstasies*, p.131.
6 There is a certain cave, on the island of Crete, where The Virgin is worshipped, on the second of February. Legend has it that she entered the cave and encountered a she-bear who turned her to stone. Here we have a clear reference to Artemis = Mary = The Mother Goddess. In America it is Ground Hog Day, a bastardization of the real thing.
8 The word *shaman* means “one who knows” in the language of the Tungus people, who live just west of Lake Baikal, in Siberia. The standard theoretical treatment of the subject is *Shamanism, Archaic
12 Initially Freud employed hypnosis in his practice, but he replaced hypnosis with "free association," because the former technique prevented him from attaining what he considered to be the requisite impersonal distance with his patients. He wouldn't even shake hands with them.
13 Zuñi: Selected Writings of Frank Hamilton Cushing. Univ. of Nebraska Pr. 1971.
15 en-theo-gen [en within + theos god or experience of god + gen producer] a soul-revealing psychoactive substance, plant or chemical, at times when used spiritually.
17 So much for the myth of the heroic scientist. The main concern seems to be for one’s career. Is science, as a human practice, a form of religion? I think so!
18 The word holotropic, of Greek origin = holos + trepein, literally turning toward the whole. The word hyletropic = hyle + trepein, literally turning toward material things.
CHAPTER FIVE
THE BIRTH OF THE MODERN WORLD

With the unknown, one is confronted with danger, discomfort and worry; the first
instinct is to abolish these painful sensations. First principle: any explanation is better
than none...The search for causes is thus conditioned by and excited by the feeling of
fear. The question: “why?” is not pursued for its own sake but to find a certain kind of
answer—an answer that is pacifying, tranquilizing and soothing.

Nietzsche,
The Twilight of the Idols

The Scientific Revolution: A Two-edged Sword.

An obvious example of this is the solid-state computer. It is a child of brilliant research in quantum
physics, conducted during the late 1940s, yoked to equally brilliant work that had been done during
World War II by Allan Turing, who led the team that cracked the German cipher system, one called
Enigma. Subsequent work done in Silicon Valley has made it possible for us to sit in front of a “laptop”
and send and receive messages, pictures, both “stills” and television programs. (I have taken some
shortcuts here, in order to remain “on target.)

But at the same time this invention makes it possible for all our e-mails and phone calls to be collected,
archived and robotically monitored. And it is happening as I write these words. Why do they do this to
us? Because they can! That’s why. And there’s the rub.

Now that we have started to collect two-edged examples, there is no point in my adding to the list, since
your fertile imaginations will add more. You have doubtless watched Mickey Mouse, in his starring role
as The Sorcerer’s Apprentice, in Walt Disney’s Fantasia. Johann Wolfgang von Goethe wrote that
story, I believe as a “warm-up” for his magnum opus: “Faust.” The original Faust legend, you will
recall, is about a scholar who made a deal with the Devil, by which he would get whatever he wanted—
in exchange for his soul. The story dates back to the very beginning of the Scientific Revolution;
Christopher Marlowe, in a flash of genius, wrote The Tragical History of Doctor Faustus around the
year 1590. He must have had a premonition, for it is the Grand Myth for our time, even more than Mary
Wallstonecraft’s Frankenstein.

The Birth Of Science—The Conventional Wisdom

Below is the standard myth concerning the conditions in Europe around the year 1600, at the eve of the
era of Descartes and Galileo, and the first birth pangs of Modernity--the standard fare in texts on the
history of science—“the Gospel.”

(1) By that time most of Europe, especially the Protestant countries in the North, had attained new
heights of prosperity and comfort, due to the growth of trade resulting from improvements in navigation
and world exploration. And it was this prosperity that inevitably gave people more time to think and
write.

(2) The invention of movable type had made possible the rise of a secular culture, whereby lay scholars,
reading and thinking for themselves, no longer recognized the Church’s right to tell them what to
believe, and began to judge all doctrines by their inherent plausibility. Turning away from medieval scholasticism, thinkers of the 17th century developed new ideas based upon observation and experience. It was from this that freedom of expression naturally evolved. (3) It was due to this 17th century insistence upon rationality, together with its rejection of tradition, that European life was reshaped. What Galileo had accomplished for science, Descartes accomplished for philosophy, freeing it from the tutelage of theology.

In this way we were taught that scientific activity is a natural product of the human intellect, in much the same way that an apple is the product of an apple tree; and that once material prosperity had been assured, once the tyranny of the Church had been overthrown, and once literacy had become widespread, there would be no further obstacles to the advancement of Science, or of Humanity.

Now then, how are we to treat this story? Surprisingly the answer is that we can look upon it as smugly self-congratulatory and mostly false--for the following reasons.

**What do we mean by Modernity?**

One of the themes of this book is the connection between the Scientific Revolution of the 17th century and the ongoing predicament that haunts us today, as inmates of the Modern World. The predicament? It is this: The Modern World is a Grand Experiment; and either its failure or its success will be a disaster for us. The word “Modern,” appears to have acquired powerful, mythological implications; and in the context of this book it has the following meaning:

(1) According to our Cultural Myth, the Scientific Revolution has given humankind the power to understand and predict, and to manipulate and control Nature.

(2) As a result of this manipulation and control, it has already become possible to lengthen the lives of some of us—the fortunate few, by freeing us, to some extent from “the ills the flesh is heir to”, e.g., hunger, disease, cold, heat, drudgery, etc.

(3) The Scientific Revolution, with an increase in knowledge and control, did not happen all at once, however; the increase in power was gradual but cumulative. After a time, this improvement in the lives of some Europeans became noticeable, and acquired the name: “Progress”, which in turn became conflated with the general Progress of the human race as a whole, (whatever that may mean).

(4) It is this cumulative nature of the technology arising from the Scientific Revolution (as predicted by Francis Bacon), that has resulted in countless situations where today’s devices and techniques are held to be superior to those of yesterday. It is in this sense that we use the word “Modern”: “state of the art”, up-to-date. Thus in my youth we were told that “today is better than yesterday,” and that “tomorrow will be better yet.” (In my youth, people took this as a kind of Divine Revelation).

(5) The changes brought about by Modern life have been those associated with vast urban complexes: the megacities, which have come to house over one-third of the world’s human population. A glance at any satellite photo of the earth taken at night is sufficient to convince one of the truth of this. Thus the mythic structure of Modern Civilization implies:

• Our urban destiny,
• supported at all times by a high degree of technological virtuosity,
• requiring the importation of vast quantities of food and energy at the expense of the rest of the world—the growing domestication of the world, the taming of Hostile Nature, and
• Great social complexity, requiring in turn equally complex, (and increasing) social controls. Visualize humans as self-domesticating, self-institutionalizing animals!

(6) Modern Civilization and Science are deeply interwoven; the fate of the one is inextricably bound up with the fate of the other. Modern institutions are assumed to be more rational than previous ones, which are presumed to have been ridden with irrational prejudices and superstitions.
(7) Moreover, this result is inevitable; so it is insane to oppose it, and therefore there is no point in giving the matter any further examination.

But at the same time of course, any program having such far-reaching and irreversible consequences as does Modern Civilization deserves the very best thought and scrutiny that we can apply. After all, habit and awareness are sworn enemies.

And it is for this reason that it is imperative for us to understand the circumstances attending the beginnings of the Scientific Revolution: the Birth of the Modern World, for there is much that is concealed behind the facade of the story line.

**The Coming Of The Little Ice Age**

We recall that already in the fourteenth century the world of Medieval Christendom was gradually starting to unravel. Historians list a number of factors, but the distinctions made between Cause and Effect are usually inappropriate in a regime as interconnected and non-linear as the world ecosystem— with the possible exception of just one factor: the pressure of population upon resources. For in this case the combined effect of over-population, the parasitic growth of urban civilization and a steady worsening of the climate, combined to put a crushing burden upon the human economy. Despite astonishing advances in human mechanical inventiveness, the land-mass of Europe could no longer support its human population. We have seen that by early in the 14th century all of the ecological niches had been filled, and combined with the falling temperatures, “the squeeze was on.” Matters grew steadily worse, for Nature seemed to have gone over to the enemy camp. At the time of The Little Ice Age of the 17th century, the river Thames was frozen to such a depth that oxen were roasted whole over bonfires built upon the ice at London. In marginal areas from 1615 on, there was a steady fall in grain yields as a result of a merciless succession of cool, wet summers, so that during that period entire villages had to be abandoned, swelling the human tide that poured into the plague-ridden cities. English society was approaching a state of collapse. At the time the poet John Donne expressed it thus:

> And now the springs and summers which we see,  
> Like sonnes of women after fifty be.  
> And new philosophy calls all in doubt,  
> The element of fire is quite put out;  
> The sun is lost and th’earth, and no man’s wit  
> Can well direct him where to looke for it.  
> And freely men confess, that this world’s spent,  
> When in the Planets, and the Firmament  
> They seek so many new; they see that this  
> Is crumbled out again to his Atomis.  
> ’Tis all in peeces, all cohaerence gone;  
> All just supply, and all Relation:  
> Prince, Subject, Father, Sonne, are things forgot,  
> For every man alone thinkes he hath got  
> To be a Phoenix, and that there can bee  
> Nonne of that kinde, of which hee is, but hee.  
> (Anatomy of the World— lines 203-218)
At that time many of the English seriously considered the end of the world to be at hand; and a year had even been selected for this event: 1657. The religious conflicts, the deteriorated climate, and the Copernican displacement of the earth outward from the center of the solar system: all of this pointed to an early end—Judgment Day was coming.

Earlier, during the 16th century, Europe, its population having been reduced by the Black Plague, and its capital holdings having increased by the tons of gold and silver plundered from Spain’s South American colonies, had been able to enjoy a brief period of prosperity, a reprieve from the general nastiness. This short respite, however, was abruptly cancelled at the beginning of the 17th century; and from the year 1618 forward, Europe plunged into a state of general crisis, similar to the terror that haunts Iraq and Afghanistan, but extending over a much larger territory.

This how it happened: After the Reformation, Europe had continued its steady downward spiral into a state of war and chaos, a condition briefly alleviated in 1555 with the signing of the Treaty of Augsburg, which stipulated that the religion of the people of a state would have to be that of its ruler. This arrangement turned out to be a poor one, even in a place such as Germany, where the individual states were small in comparison to the size of the region that was home to the German nation; for it still produced large displacements of people, accompanied by a great deal of human misery. But in other nations the German solution was not even remotely workable, since there was no place for people to go. This fact accounts for the great attention that was paid to the French experiment, and to its highly respected creator, Henri of Navarre, King of France, which was the most powerful nation on the continent. The future of Europe lay in the balance, and therein lay the significance of his murder.

What effect did the assassination of Henri IV have on the situation as it stood in Continental Europe? Across the Rhine, the German Empire, a patchwork of states and principalities stretching from the Netherlands to Bohemia, and from Bavaria to the Baltic, had become a powder keg. This huge land was ruled by an emperor who had been, in turn, chosen by a committee made up of seven electors. Some parts of the Empire were Protestant, and some were Catholic. There were four Catholic electors and three Protestant ones, (a piece of gerrymandering engineered earlier by the Catholic Church). The most powerful of these politicians was the Duke Of Austria, a Catholic, who was a close cousin of the King Of Spain, both of them members of the Hapsburg family. A shift of one elector from the Catholic side to the Protestant side would be intolerable from the point of view of the Duke of Austria, but in the year 1618, that is exactly what took place. And with the King Of France out of the way, there was nothing to stop the two cousins from using this as a pretext to reassert Hapsburg power over Central Europe, since the heir to the French Throne at that time was but a sickly child. This, then, was how the Thirty Years’ War broke out. In 1648, by the time the hostilities had finally subsided, 37 percent of the population of Germany had met violent deaths, and the farms and villages of Germany and Bohemia lay in ruins.

In addition, England fell into a state of civil war in the year 1640, remaining in a state of chaos (not all bad) for nearly ten years. At the end of that time, parliamentary rule was established, the king beheaded, (a good start), and a few tentative steps made in the direction of 1787, and the world of Madison and Jefferson. The reason for all this slaughter? It was the long, slow disintegration of the feudal structure of the Middle Ages.
If the Received View is Not the Correct One, What Then, Was the Actual Truth About the Early 17th Century?

• The early 17th century was really a time of major financial disaster, brought about by war, depression, and bad climatic conditions.
• Religious intolerance was at its worst at that time. France had just emerged from a period of bloody religious war, which had lasted for 36 years. And the 30-years’ war in Europe was mostly a result of religious fanaticism.
• When we compare the literary figures of the 17th century with those of the previous one, it can be seen that the horizons of the imagination had become severely contracted. The 16th century was the century of François Rabelais, Michel de Montaigne, William Shakespeare, Miguel Cervantes and Christopher Marlowe. These luminaries were followed by a time of almost total literary eclipse. (Much like today!)

Enter René Descartes, A Key Player In The Drama.

René Descartes was born in 1596, at La Haye, in the West of France, in the broad valley of the Loire. He received his schooling at the Jesuit college at La Flèche, the land for which had been donated to that religious order by the King himself, Henri IV. Descartes showed remarkable mathematical ability at an early age, inventing analytic geometry, a technique that enables one to assign algebraic equations to geometrical figures. It was after leaving La Flèche that Descartes had come to the realization that the obscurities of medieval philosophy, which had been the standard curriculum there, had taught him nothing that he could hold for certain.

For a while he drifted, supporting himself briefly as a gambler; and when war broke out in Central Europe in 1618, the young René Descartes found himself attached to the army of Prince Maurice Of Nassau as a “gentleman observer”. After the rout of the Protestant forces at White Mountain in Bohemia, the Catholic army to which he was attached took up winter quarters at the city of Ulm, in Bavaria. And it was there that, while spending a night in an overheated room, Descartes had three powerful dreams, depicting the obstacles that he must face in his quest for certitude.

In his determination not to be deceived, Descartes resolved initially to doubt everything. This, he believed, was the necessary first step in the direction of Truth. In the process of doubting everything, even the apparent reality of the physical world, Descartes discovered what was for him the bedrock of human knowledge: the certainty of his own existence, implied by the fact that he could doubt. Hence: Cogito, ergo sum: “I think, therefore I am,” set down in his book: Discourse On Method. The word: cogito, I “think”, was the first principle of knowledge for Descartes; it was also the basis for all his subsequent deductions. Avowing his own existence was an admission that he was a finite, imperfect being. From this premise he deduced the necessary existence of a being who was indeed both infinite and perfect: namely, God. Since God, being perfect, would not deceive man, as well as his reasoning ability—that which gives him such self-evident truths, it followed that the reliability of human reason is thereby assured. It may have come to the reader's attention that there is more than a suspicion of logical circularity here. Descartes thinks; from this he deduces God; but then God becomes his guarantee that he thinks correctly. But Descartes was living in desperate times, when the foundations of European Civilization had been badly shaken, so he was therefore eager to grasp at any straw that might present itself. Human sense perception can be easily deceived by appearances, he thought, but surely not the light of human reason. It was by this (to us, shaky) reasoning process that Descartes was able to establish (to his satisfaction) a fundamental article of Belief of what would be called today: The Western Rationalistic Tradition, namely, the objective reality of the world of phenomena, as presented in the
A century before, Martin Luther had taken as his motto: Credo, ergo sum: I believe, therefore I am. But Luther had been a man of faith; whereas Descartes was placing all of his faith in his own reason. In so doing, he had moved Reason to the center of the stage, forcing it to play a role for which it was not entirely suited. In this sense Descartes was the father of modern rationalism. (I would hope that most of us would prefer to assign primacy to Experience.) Benjamin Franklin said: “Experience keeps a dear school, but a fool will learn in no other.”

By the time Descartes had reached adolescence, Galileo had already discovered the predictable, mechanical behavior of bodies in the external world¹¹: a kind of motion that was strictly deterministic. Effects followed blindly from causes, with no apparent purpose. But, what about the internal world? Was it, too, destined to be the plaything of determinism? Essential to the Christian tradition, however, is the notion of Free Will. After all, what is the point of The Last Judgment, heaven and hell, if men and women are merely robots? (All that work on the Sistine Chapel Ceiling for nothing?) This was the question that became the source of the famous Mind-Body Dichotomy; and for its solution Descartes was forced to postulate a rigid dualism. External to the soul is the res extensa, all material substances located external to the rational mind, substances whose behavior is strictly deterministic. The soul is the res cogitans, a spiritual, rational, immaterial substance exhibiting Free Will. Only in humans did those two entities come together; and even then only at one tiny point, which Descartes located in the pineal gland, situated near the base of the brain. Only there did the material and spiritual meet—and only tangentially at that.

It is this dichotomy between matter, which operates causally; and spirit, which exhibits purpose, is the source of Cartesian Dualism: a dualism of Mind vs. Body, Spirit vs. Matter. In the sphere of Matter are found stones, machines, plants, cheeseburgers and all animals exclusive of humans. To René Descartes all of these, even the other animals, are mere automata: soulless, devoid of emotions and feeling. To Descartes, the agonized screams of a tortured animal did not signify real pain; they were merely mechanical screeches. As a result, this pernicious notion has long served as a rationalization for countless acts of vivisection and animal experimentation¹². For Descartes, the only spiritual thing about a human is the Soul: immaterial, and--most important: the font of Reason.¹³ Thus the real meaning of Cogito, ergo sum, is: “I am a spiritual substance, which has nothing corporeal in it.”¹⁴ The implications are clear: according to Descartes, we are not to be identified in any way with our bodies—or with the rest of Nature for that matter. The Universe of Aristotle and Aquinas had been considered to be a living, female being: Natura: Mother Nature. But the universe of Descartes was one that was inert, mechanical, and inherently measurable, (and disposable, too). This was a time when, for a person to consider the natural world to be in some sense alive was, in Roman Catholic and Protestant circles, becoming regarded as a scandalous act of impiety. Animism was actually considered to be a form of atheism. One of the fathers at Descartes’ alma mater, the Jesuit college of La Flèche, Louis Lallemant, had this to say about Nature: “We should feel wonder at nothing at all in Nature except only the Incarnation of Christ.”¹⁵ However, a moment would come when humans no longer believed in God’s power to regulate the mechanism of the order of nature, and the little wheels of the human being and the automatistic ones of the beasts would proceed to tick over on their own. In this manner the Cartesian rationalists set the stage for the Death of Nature ¹⁶.

**The Birth Of The Mechanical Philosophy**

What were the origins of this new philosophy? At the time of the Italian Renaissance (the year was 1417), scholars had rediscovered a poem: De Rerum Natura (On The Nature Of Things), by the Roman poet Lucretius. Lucretius had been a disciple of the Greek philosophers, Epicurus and Democritus, the
men who had founded what we call the atomistic philosophy, a doctrine which can be summarized by
the famous Democritean quote.17

**By convention sour, by convention sweet, by convention colored: in reality nothing but atoms and
the void.**

Democritus’ philosophy, especially as interpreted by Lucretius, had been ill suited to the spirit of the
Renaissance, since Neo-Platonism, heavily flavored with magic, was still the dominant mode of thought
in the fifteenth century. But by the 1620s Democritus was a philosopher whose time had come. His new
champion was Pierre Gassendi, a Catholic priest (of all things) who was a colleague of Marin Mersenne,
a monk who acted as Descartes’ sponsor. (In this mafia, who was the *capo*? Answer: Cardinal Richelieu,
the king’s minister).

Atomistic philosophy was to find its way into political theory, also. The Framers of the American
Constitution had imbibed the idea of a free person, seen as a political atom, from the English
philosopher, John Locke.

**What are The Essentials Of Mechanism?**

- All of the phenomena of the World can be described, represented, in terms of Matter and Motion,
  which in turn follow the laws of mechanics.
- Matter is in turn composed of atoms.
- There may or may not be a subtle substance called the ether, a kind of plenum or reservoir, in which
  the atoms have their motion. If the ether turns out to be absent, then matter moves through The Void.
- The Motion of the atoms is not intrinsic to them; their motion must always come from without. Atoms
  are not “alive” in any sense. In Gassendi’s religious interpretation, the motion of atoms was induced at
  the Beginning, by God; (who then went away on vacation).
- The mechanical representation of the World has to be a completely faithful one. That is, when we think
  about Nature, we are “holding the mirror up to Nature”; the complexity of the mind-stuff and the
  complexity of the World are commensurate with each other, so that the mind can comprehend the World
  exactly.18
- The Appearances can be “Saved” completely; so that The Map will be identical to the Territory.
- The Real World is the one that our Map shows-- (after we have been safely subtracted from it). Thus
  the accepted view is: The View From Nowhere.

**More About Descartes**

It was a strange paradox: here we find Descartes, Mersenne and Gassendi, three Roman Catholics,
joining forces with the English philosopher Thomas Hobbes (a devout atheist), to create the philosophy
of Mechanism, in the interests of restoring public order, banishing magic, and perpetuating European
Civilization19. Mechanism is, of course, a philosophy that would not only come to threaten the
hegemony of all organized religion, but would also come to deny humans any significance at all in the
cosmos. But there is a haunting resemblance here to Book X of *Plato’s Republic*, in which *reason* is held
up as the ultimate guarantor of the social order. Although his initial inspiration had come from his
dream in the year 1619, Descartes, to be consistent with his rationalist philosophy, actually distrusted
dreams and other manifestations of the Unconscious Mind.

And the actual life of Descartes? He lived most of his adult life outside of France, spending most of this
time in Holland, which was known as a haven for Free Thinkers. The condemnation of Galileo in 1633 had come as a terrible shock to him, making secrecy even more desirable. Thus we shall never know what Descartes’ true opinions were; after all, his personal motto was: *larvatus prodeo* —"I present myself masked". (It is very awkward to have had one foot in the Scientific Revolution while keeping the other one in the Vatican—Ask me how I know!) He died in Stockholm in 1650, and was buried in Paris, in the church of St. Germain des Prés—with the exception of his skull, which is also preserved in Paris—but at the Musée de l’Homme, the Anthropological Museum. There must be a cult of skull-worshippers in Paris!

**What are the distinguishing marks of Cartesian thought?**

[1] It is based upon formal reasoning, with Euclid’s geometry taken as a model. With Euclid we start with self-evident axioms and postulates (what Descartes called: “clear and distinct ideas”), advancing little by little, to more complicated statements that we call theorems. It must be said here that Descartes viewed Euclid with some disapproval, on the grounds that he was lacking in sufficient rigor; after all, Euclid’s axioms and postulates were allowed to go unproven—he took too much for granted. A die-hard Cartesian will start by assuming absolutely nothing. As we shall see, Descartes had a neurosis, and its name was Certainty.

[2] Practical matters or special cases are of little interest. Descartes was seduced by the abstract power of a Euclidean proof—its generality. An abstract proof must be independent of context. Its power lies in the fact that it holds in every case—one size fits all. This type of thinking is highly invasive; there is an overpowering temptation to rely upon it to solve all human problems, for it appears to be The One Right Way.

[3] And there is only One Right Way: the Cartesian Method for ascertaining the truth in all fields of knowledge. The more practically oriented Aristotle had urged his disciples not to aim at certainty, necessity or generality beyond “the nature of the case”. Thus Descartes, in his enthusiasm for theoretical reasoning, gave to the intellect a priority that it had never before enjoyed—and one that it doesn't really deserve.

[4] We have to re-invent philosophy from scratch. Descartes did not advocate throwing the work of the older philosophers into the trash barrel, but he did insist upon subjecting their theories to the scrutiny of the Cartesian Method.

[5] His very use of the mind was mechanical. We have seen that Descartes conceived of the world as a piece of clockwork; we notice that his method for using the intellect to solve problems is likewise mechanical. It is a method for taking machines apart and reassembling them; it is never a method for inventing or discovering anything. It is a set of instructions for linear thinking. Since the most fundamental reality for Descartes was his own thinking, everything he subsequently touched upon was condemned to be “theory-based”.

[6] In order to yield valid knowledge, the Real World must be simplified, de-contextualized, into a theoretical construct. If you wish to apply the Cartesian method to studying a cow, the cow can be assumed to be a spherical, or possibly a cylindrical one; in that way the mathematical treatment becomes more straightforward. But it is the context that provides the meaning; if you ask for the meaning of something, you are asking for its context: a semantic question. Anything taken out of context becomes meaningless; (it smacks of schizophrenia).

**Is it possible for Descartes’ philosophy to be valid even if it has a neurotic context of its own? Here the Reader Must Decide…(good luck with that).**

The power of the Cartesian method is its perfect generality, its absence of context: it is supposed to work
in the same way as a high school geometry textbook, serenely analyzing the universe. But what was its significance for Descartes? Was it just an airy exercise in abstract thought? It is only fair to ask if this exercise in non-contextuality had a hidden context of its own. Did the development of the Cartesian Method have a “hidden agenda”? According to the Cartesian program of systematic doubt, The Real Cartesian Truth is by nature context-independent, so that there couldn’t be a context to Cartesian thought! A Cartesian would probably tell you that it sprang like Athena, full-armed from the brain of Zeus. But this is nonsense! In short, what was driving that man? At the time Descartes was writing, we have seen that Europe was submerged in a Thirty Years’ War. The actual fighting took place in Germany, but the real antagonists were France and Spain: a proxy war. The leader of the French forces was Armand Jean du Plessis, better known as the Cardinal Richelieu. Richelieu worked tirelessly, ruthlessly, for the purpose of re-establishing order at home, while conniving abroad to engineer the defeat of Spain. And Descartes was, albeit indirectly, really Richelieu’s protegé—one of his shock troops. Thus Descartes was working in an ambience of fear: fear of anarchy, and of intellectual and religious chaos, of all against all. He was in fear of himself. What if he could not prove the existence of God? Faith was of no use, as we have seen; for he had no recourse, save his own intellect. This mental trap produced incredible quantities of anxiety—anxiety that have for centuries plagued people, even during my own lifetime, especially Roman Catholics in Europe and America. The impossible goal of Descartes was to refine the “machinery” of the intellect in such a way as to produce overwhelming religious certainty—the kind of certainty which would unite all in agreement, Catholics, Protestants and Atheists, to ensure the continuity of European Civilization, as well as harmony between those newly created dualistic poles, the Natural and the Supernatural.

Before the 17th century, and its attendant bloodshed, the religious position taken by the leading writers and philosophers (worldly, sensual spirits such as François Rabelais and Michel de Montaigne), had been one of tolerant skepticism. By the 1630s there was no further room for either tolerance or skepticism. Instead, men like Descartes and his direct sponsor, Marin Mersenne (Richelieu’s Commissar Of Culture), were prepared to sacrifice everything else in trade for certainty, order and control. At the time that Descartes was a student at La Flèche, Montaigne’s essays had been part of the required reading for every French schoolchild. In one of these essays can be found these words:

“Unless some one thing can be found about which we are completely certain, we can be certain about nothing.”

We can imagine young Descartes, then, overwhelmed by anxiety over the future, dreaming of the day when he will take up the challenge: “Can’t I be certain that I doubt? If so, I must be thinking. How can I think, if I don’t already exist?” Thus Cartesian philosophy was not formulated in a vacuum, but rather as an attempt, in sorely troubled times, to refute the genial, tolerant Montaigne, and to replace his gentle brand of skepticism with the intolerant Cartesian variety, in which everything is held as false unless it can be proved to be true--guilty unless proved innocent. This, then, was the missing context: it was one of existential anxiety. This quest for certainty was the drowning person’s grasp for a straw. One can almost hear Descartes say: “When you’re in trouble, when you are in a state of extreme emergency, you need to be rigorously logical, or you’re lost.”

We have seen that by the 17th century the house of cards that was Medieval Civilization was undergoing a long collapse, and the desire to put it back in order gave rise to a philosophy that was tight, narrow and “theory-bound”—and more than slightly mad. But there is more to the story than that. For by now, Cartesianism, like a virus, has so thoroughly infected Western thinking, and so completely infiltrated our vocabularies, that we have become largely unaware of its existence: Today we can speak of "Mind
versus Matter” without giving it a moment’s thought.24

For Descartes, the body was nothing more than a kind of “meat vehicle”. As a result, much of the history of modern medicine has been a saga of the invention of emergency high-tech responses to pathologies incurred by individuals who have resolutely refused to accept responsibility for their own bodies—massive interventions, undertaken at the eleventh hour (doubtless on the grounds that “this body isn’t really Me; I just live up here in the pineal gland...”).

Finally, it is necessary to point out that by a paradigm we mean a pattern.25 What, then do we mean by the Cartesian Paradigm—a phrase that had been in considerable use during the past century? The Cartesian Paradigm is simply a complex metaphor for dealing with reality. For one thing, the Cartesian method of thought is identical in pattern to the way in which one would repair a broken machine, say a clock. We take it apart, down to its smallest cogs, its atoms of machine-ness—until we can go no further. Then we reassemble it (replacing parts when necessary). If the universe is a piece of clock-work, mechanical and dead, then the method of studying it must also be mechanically-inspired. The Cartesian whole, then, is merely the sum of its parts—no more, no less. Once this method has been found to work in some cases, it became the recommended method for every case. And the Cartesian method is supposed to be independent of context. In the next chapter we shall see how Cartesian physics was refuted, but his method was applied to the Universe by a strange, twisted man, The Last Of The Magicians: Isaac Newton.

What it All Meant to a Kid Growing Up in the Mid-Twentieth Century

At the time I grew up in San Francisco during the 1930's and 40's, there was little or no doubt about the merits of modernity. We all considered ourselves lucky to be born in this time and place, rather than under the precarious conditions experienced by our unfortunate ancestors. Were we not living in the Land Of The Free? The end of the Second World War had brought about the defeat of the forces of racist irrationality, and therefore we had every right to expect that it would be only a matter of time before peace, freedom and prosperity would be the lot of everyone in the world. We were confident that the age of massacres was over. As a child I had attended the 1939-1940 World’s Fairs both in San Francisco and in New York. There I had an opportunity to view the latest technology, full of promise of better things to come. In my late teens I was employed at the original United Nations Plenary Session in San Francisco, and at the time I naively imagined that the statesmen who addressed each other from the podium were actually there for some altruistic reason. The Forces Of Good seemed to have won a definitive victory, and those were stirring times. Everything that I had seen and heard in those days of euphoria seemed to vindicate the program of Modernity, and I believed with all my heart that the engine that was driving Modernity was the progress of Science. And, in a way it was. I wanted to be a part of it. As long as the cornucopia of Science was continuing to produce “quasi-solutions,” and the residue problems had not yet appeared, then the progress of Science seemed to be at one with the progress of humanity. I was a good student, for I had so much to learn....

Notes to Chapter Five:
(1) Friedrich Wilhelm Nietzsche, 1844-1900. German philosopher.
(3) All of the urban amenities depend on food, energy and raw materials. None of these are produced by urbanites. Hence the function of the city is extractive: a parasite upon the landscape.
Presently (2012) ascribed to the effect of a gigantic volcanic eruption that took place on an island near Java in about the year 1270.


Many people thought that the change from a geocentric picture to a heliocentric picture involved a physical displacement!

It seems as if the horrified fascination that the Afghan tragedy has for us is in part due to our suspicion that this is the normal state of affairs in the world, and we ourselves constitute but a temporary exception.

The usual name given for this political entity is the Holy Roman Empire, whose rulers proudly traced their legitimacy all the way back to Charlemagne, but for reasons of clarity it is useful to “call a spade a spade”.


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Strangely, in his writings Descartes disparaged dreams, claiming that they are not a source of useful knowledge, since their content is not “clear and distinct”.

Galileo’s works, though condemned by the Church, were in the library of the priest Marin Mersenne, in Paris. Mersenne in turn made them available to Descartes. Rome’s rules didn’t hold in Paris.

See: *When Elephants Weep*, by Gregory Moussaievich Masson, for a fascinating discussion of this question. Do beasts have feelings? Do they feel love, hate and fear? Animal behaviorists claim that we merely anthropomorphize when we ascribe any human characteristic to other animals. Why? The animal behaviorist is conditioned to believe thus. Professional animal handlers know better.


“Je suis une substance immatérielle, et qui n’a rien de corporel.”

Speaking on the subject of this quote, Aldous Huxley remarked: “In the seventeenth century Lallemant’s phrase seemed to make sense. Today it has the ring of madness.”


Democritus: a Greek philosopher; exponent of atomism 460-362 B.C.

This last notion seemed perfectly reasonable at the time. Those who had hoped for a Theory Of Everything are beginning to wonder. How can the Mind comprehend the World when it is a part of that World? Is it like pulling ones-self up by one’s bootstraps?

This should not be taken to mean that all four men had the same identical philosophy. They were all very different people. But the effect of their joint effort was The Mechanical Philosophy.


Here is my own direct translation of what Descartes said:

“The first precept is for me never to take anything for the truth when it is not obvious to be such: that is to say, to avoid haste carefully, as well as forming an opinion, and not to include any more in my judgments than which presents itself clearly and distinctly to my mind in such a way that I would not have any occasion to put it in doubt.

“The second is to subdivide each of the difficulties I wish to examine into as many parcels as possible, and as would be required to better resolve them.

“The third is to order my thoughts, commencing with those objects which are simplest and most easily understood, to advance, little by little as by degrees, arriving at an understanding of the most complicated: even assuming an order among those which do not precede one another naturally.

“The fourth is to make everywhere so complete an accounting, and such general reviews, as to be sure of
having omitted nothing.”

(21) Unfortunately space does not permit a complete discussion of the collision of the disintegrating European social structure with the will of this ruthless politician, out of which emerged the nation-state that has been such a familiar fixture on the world map. At home, his drive to dominate crushed the power of the independent French nobility, and split the Protestants into factions which he then pitted against each other. He established the Académie Française for the purpose of standardizing the French language, and suppressing the rich profusion of colorful dialects spoken in his country—the reason that the French language is so monstrously inflexible today. His agent Mersenne understood the power of music to sway the mind from the straight and narrow path of rationality; so determined he was to control this, that he proceeded to lay the groundwork for the orderly classical music of the Baroque period. Mersenne had been deeply concerned about the proliferation of occult secret societies in Europe; moreover, the profusion of alchemical treatises published in Paris during the 1620’s provoked him into establishing academies for the purpose of extirpating that field of study. At the time of Richelieu’s death a prominent Italian remarked: “If there is a God, he will have much to answer for; but if there is not, then he was a good man.” This illustrious Italian, another Baroque personage, who was that Italian? It was the Pope, Maffeo Barberini!

(22) This form of pathological rationality, called rationalism, has been used to distort the emotional development of every French child since the Revolution. And not only in France! A Cartesian skeptic is one who treats any proposition as false until it is regularly demonstrated in a laboratory. We have all met one or more examples of this genre, and wondered about the origin of the syndrome. Before the time of Descartes, a skeptic was merely a person who maintained an open mind, neither asserting or denying any proposition, until it was examined, and compared with experience. At the time after the Reformation, educated Europeans were especially influenced by the writings of the Greek skeptics, the most famous of whom was Pyrrho, founder of the school of Skepticism, and a contemporary of Aristotle.

(23) This quote is from the essay, Apologie de Raimond Sebond.

(24) The impact of the French Rationalists on the rest of Europe became enormous—especially after the Revolution. The results of the Cartesian political spirit can be seen by anyone who studies the aftermath of the French and Russian revolutions. There is more than a touch of Rationalism evident in the Seal of the United States: Novus Ordo Saeclorum”: “a new order of the ages. At this writing the “new order” is beginning to look like a re-run of those past “new orders: like the Roman Empire, for instance.

(25) Paradigm, comes from the Greek: para-deigma: a pattern in the sense of a template. The kind of pattern used in making garments.
If we evolved a race of Isaac Newtons, that would not be progress. For the price Newton had to pay for being a supreme intellect was that he was incapable of friendship, love, fatherhood, and many other desirable things. As a man he was a failure: as a monster he was superb. 

Aldous Huxley.

The shadow cast by Isaac Newton has lain across the landscape of world history for the past three hundred years. It was his fate to be “just the right man at the right time”— for a Civilization that was going mad.

Vital Statistics: His Birth

Isaac Newton was born on Christmas day, 1642, the year of the death of Galileo, in the tiny hamlet of Woolsthorpe, in the fen country of Lincolnshire, not far from the medium-sized town of Grantham where Newton attended grammar school. Today in Grantham, there still stands the tall white church steeple, watching censoriously over the crowds of shoppers at the new red-brick Isaac Newton Shopping Mall, close by the track of the fast train that runs from London to Edinburgh, paralleling the old Roman road that first linked London to York. In the surrounding Lincolnshire countryside, great round hills rise unexpectedly out of swampy, poorly drained areas, while the whole land mass slopes off gradually in the direction of the North Sea. It is a place where the climate is relatively mild, and where grazing sheep have tried unsuccessfully for centuries to denude its sleepy hillsides.

[I] A Bit Of Essential History

The Situation in England during Newton’s times: from 1642 to 1700

During that same year, civil war broke out in England, between the Royalists, loyal to Charles I on the one side, and on the other side, the rebels, who supported the supremacy of the English Parliament. The rebels comprised a coalition of Protestant groups, most of whom were Calvinists or Baptists, and who were determined to end the hegemony of the Established Church. After 1641 the strict press censorship that had been formerly exercised by the Crown was lifted, and in the general confusion, an epidemic of freedom of thought and expression broke out. The immediate effect was that thousands of copies of the Bible came into existence in England, as well as books on alchemy, astrology and other forms of hermeticism. Temporarily rescued from supervision by the Established Church, the common people produced a lush undergrowth of Pentacostal sects, falling into trances and speaking in tongues— while other more creative types started to practice sorcery and magic. At that time it was customary to refer to the broad spectrum of these Pentacostal phenomena under the pejorative heading of: Enthusiasm (from the Greek:literally “inspired, or possessed by gods”). Those who exhibited these phenomena were referred to as enthusiasts. Altered states of consciousness were being freely accessed again, after centuries of persecution.
By 1642 it had been clear for some time that the Old Order was passing away. Its Myth was dying. But that old feudal order, for all of its vertical and horizontal social immobility, had also for centuries been the very glue of social cohesion. Almost everyone had had a place in the Old Order, a station in life—an identity. Before the times of scarcity there was neither unemployment nor employment; there was only status. One didn’t exactly have a “job”, and certainly no one had a career. Instead one had a “station in life”, a station presumably divinely ordained by the Providence, which had supposedly placed them all on earth in the first place. This was the very essence of the Old Order: stasis, and relative security. But by the Elizabethan period, (1558-1603) already England had repeatedly experienced periods of dearth (times when the country’s harvest was not sufficient to feed its population). Economic breakdown produced social unrest. Really, peasant revolts had already been occurring sporadically across the land for a period of more than 200 years.

After war broke out in 1642, England fell into political chaos. To bring this chaos to an end it would become necessary to invent a New Order—to re-invent English society. In the 16th and 17th centuries a vast amount of arable land--The Commons-- had been confiscated by order of the Crown, for the purpose of sheep-farming, and thousands of people had been displaced. In the words of the historian David Kubrin:

*When many of these people were unable to find employment in the towns and cities, they became justifiably angry; and at a time when some of the fundamental institutions and values of the society were being challenged, they demanded that all of them be questioned.*

And so it came about that a profusion of radical politico-religious groups sprang up, people of the “underclasses”—“enthusiasts”, bearing colorful names such as: Levellers, Diggers, Muggletonians, Friends (the Quakers), The Family Of Love, Fifth Monarchy Men, Ranters, and others. As interesting as these “sectarians” were, however, they were ultimately denied an opportunity to organize the New Order. At the beginning of the war the Parliamentarians had needed their help to secure the overthrow of the Monarchy. But after the King was beheaded in 1649 and the Monarchy supplanted by a Protectorate under Oliver Cromwell, the sectarians were discarded; they had become inconvenient. One thing had become clear: the new social order would have to be one that was acceptable to the landowners and the rising capitalist class, whose agenda was completely at odds with that of the sectarians. Consequently, well before the Restoration of the Stuart Monarchy in 1660, the “sectarians” had fallen out of favor with the power structure, and with them had fallen magic, alchemy, astrology and hermeticism. An interest in “under-class” subjects such as these would mark one as deserving of suspicion on the part of the authorities, who were members of Establishment--the Church of England. But it is useful to remember that counter-cultures never die; they merely go underground, and centuries later, even after the most ferocious persecution, some version of them re-emerges in the same localities where they had flourished in the first place.

During the 1650’s it had become clear that England desired something more stable and less brutal than the Cromwellian Protectorate; therefore, after the death of Cromwell in 1658, influential Parliamentarians began negotiations with the son of the late King, who had sought refuge in Holland. Thus it came to pass that in 1660 the Monarchy was restored, and the young pretender was duly crowned as Charles II. In accordance with the Settlement the actual governing power rested with the Parliament, and the King was but a figurehead, devoting his energies to the stalking of women and partridges. But the privileges of the nobility were also restored, and the Church of England reestablished. How galling it must have been, after having enjoyed freedom of Religion for eighteen years, to find one’s self again required to attend Anglican church services on Sunday, and to be again
It was in 1662, early in this period called the Restoration, that young Isaac Newton departed from Woolsthorpe for Cambridge, where he would spend most of his time for the next thirty-five years. The atmosphere at Cambridge after The Restoration was a strange one; a number of the faculty had recently been purged for politico-religious reasons, and the dour Calvinism that previously distinguished the place had given way to a milieu publicly characterized by loyalty to king and church, and to the training of students for the ministry. Privately the majority of the students devoted their time to gambling and whoring. At that time there was an unwritten law that one must not inquire into another’s religious beliefs; for it would have been disastrous to be found out as a closet heretic. Expulsion and disgrace inevitably followed this kind of disclosure. Further, magical practices were widely held to be politically radical and “underclass” in provenance. Experimenting with sorcery was experimenting with treason and damnation.

In England this situation continued in a relatively stable fashion until the death of Charles II in 1685, at which time a certain problem arose over the succession to the throne. Charles had fathered numerous children, but they all happened to be illegitimate. It was therefore decided that Charles’ younger brother James would inherit the throne; however, this arrangement was the source of grave doubts in some circles—doubts that turned out to be amply justified. It turned out that James was a Roman Catholic, and even worse, that he had learned nothing at all from the recent Civil War, which had cost his father’s life. James tried to force his will upon the British by force of arms, but he lost the war. The year 1688 became known as the year of The Glorious Revolution, in which James was deposed by Parliament, and replaced by William Of Orange of the Netherlands. A staunch Calvinist, William had no great fondness for the Church Of England, and soon persuaded Parliament to pass the Toleration Act, which then led to the Broad Church Compromise, eliminating compulsory church attendance. After that time, interest in religion fell off drastically throughout an England that was enjoying an unprecedented economic expansion.

[II] Newton as a Person

“There is no roome for mee to sit.”—The Child Newton

At the time Newton was born, Lincolnshire was a Puritan stronghold. Because its farmers had been early supporters of the victorious Parliamentarians, the countryside was spared most of the rigors of war. But early in his life Isaac was plunged into his own pit of misery; for when he was three years of age, his mother remarried—this time her husband was the wealthy (and lusty) Reverend Barnabas Smith, aged sixty-three. After her marriage, his mother moved to the house of her new husband, in the nearby town of North Witham, leaving wretched little Isaac behind in Woolsthorpe in the care of his grandmother. Eight years later the Reverend Smith died, and Newton’s mother returned to Woolsthorpe, bringing three more children with her. But by that time the absence of his mother had already left him permanently scarred, as the surviving evidence indicates.

According to his biographer, Frank Manuel.

“Newton’s mother is the central figure in his life.... They were in union with each other during a crucial period, and his fixation upon her was absolute. The trauma of her original departure, the denial of her love, generated anguish, aggressiveness, and fear. After the total possession—undisturbed by a rival, not even a father, almost as if there had been a virgin birth—she was removed and he was abandoned.”
The Young Sinner
There is plentiful evidence that young Isaac continued to harbor a burning resentment against both his mother and his step-father well into his twentieth year, a time when the Reverend Smith had already been nine years dead. For as late as 1662 Newton recorded a list of his “sins” in a notebook; among them, according to Manuel, is this confession: “Threatening my father and mother Smith to burne them and the house over them.” In the grim, predestinarian, Calvinist matrix in which the boy Newton grew up there was no provision for forgiveness of sins; therefore, when he studied his murderous impulse, he could see it only as a portent and token of inevitable damnation. The youthful Newton seems to have left a generous paper trail, and Frank Manuel’s biography contains an extensive selection of material, some of it of a most embarrassing nature. As Manuel says:

In all these youthful scribblings, there is an astonishing absence of positive feeling. The word ‘love’ never appears, and expressions of gladness and desire are rare. Almost all the statements are negations, admonitions, and prohibitions. The climate of life is hostile and punitive.

A Search For The Father
The inner life of the believing Calvinist is an almost unbearable one, and at some early point, certainly well before his twenty-eighth year, Newton had become a secret Unitarian. The issue here is a complex one, for Calvinism is even more a state of mind than it is a set of credos, and the ingrained attitudes easily oulive the details of the religious doctrines— and go on to become indistinguishable from the axioms that underlie modern capitalism. But there was also an equally profound reason for this shift in allegiance; one which can be discerned from an anagram scrawled in the margin of an alchemical treatise: \( \text{Isaacus Neutonus = Jeova unus sanctus} \) Since Isaac Newton had never known a father in actuality, it was all the more important to find him spiritually. Thus there would be only one Father and one Son, so that Newton could only be a Unitarian—a conversion that seems to have occurred early in his life. There was an intensity to his secret belief, one that goes far beyond theological argument. In 1690 Newton even sent an anonymous letter to be printed in Holland, in defense of Unitarianism, However, realizing that its authorship would be recognized, he prudently withdrew it.

Given that Newton’s entire upbringing had been structured by the words of the Bible, it would be astonishing if he had not likened himself to the Biblical Isaac, who was spared by Jehovah, and therefore by his father Abraham. Newton, whose survival of infancy had bordered on the miraculous, was also a posthumous child. It is widely believed in some societies, that posthumous children are endowed with supernatural powers. In fact, there is a tradition in Lincolnshire, lasting to this very day, by which posthumous children are destined to good fortune. Moreover, Newton was born at Christmas—an omen of future greatness. Later on, as a young man he was spared from death by the plague, a disaster that had carried off at least 68,000 people in the city of London alone. Therefore, Newton had the psychological profile of a “survivor”; and survivors frequently exhibit mysterious surges of creative power.

Newton was conscious that his special calling was divinely inspired. According to Manuel’s analysis:

The more Newton’s theological and alchemical and mythological work is studied, the more apparent it becomes that in his moments of grandeur he saw himself as the last of the prophets, living on the eve of the fulfillment of the times. In his generation he was the vehicle of God’s eternal truth, the greatest of all time perhaps, for by using new notations and an experimental method he combined the knowledge of Israel’s prophets and the Greek mathematicians and the medieval alchemists. From him nothing had been hidden. But Newton’s insistence that he was part of an ancient tradition, a re-discoverer rather than an innovator, is susceptible to various interpretations. In
manuscript scholia to the Principia that date from the end of the seventeenth century he expanded his belief that a whole line of ancient philosophers had held to the atomic theory of matter, a conception of the void, the universality of gravitational force, and even the inverse square law. In part this was euphemistic interpretation of myth—many of the Greek gods and demigods were really scientists; in historical terms this is a survival of a major topos of the Renaissance tradition of knowledge and its veneration for the wisdom of antiquity.:

The Apple And The Moon

It was during the plague years (1665-66) that Newton was persuaded to take refuge at his mother’s farm at Woolsthorpe; and in later years he claimed that it was on her farm that he made his first grand discoveries. The tale he told was a pretty one, and one which he seems to have invented long after the fact. Still, it contains the essence of Newton's contribution to human thought, and so we shall recount it here. It makes for a good story.

First we need to recall that Galileo (with whose works Newton was familiar), had learned to describe the trajectory of a projectile as a parabola—a smooth curve. Accordingly, the path of the projectile is also smooth and continuous, so that the projectile must pass through every single point on it; and for every instant of time there belongs a point on the trajectory. From this insight Newton deduced that there is an associated velocity—an “instantaneous velocity” belonging to each point on the projectile’s path. And from there it was a major linguistic leap to learn to speak of each change in the instantaneous velocity as the result of something called a “force”. The last piece in the jigsaw puzzle was mysterious, even magical: it was the idea of Universal Gravitation. All of these lines of his thinking converged to produce the science of mechanics and the differential calculus, both of which were Newton’s discoveries, and both of which formed the pillars of the temple of classical physics.

It was at this point that Newton claimed to have turned his eyes upward, and compared the fall of the apple with the path of the moon. Clearly the apple fell to earth by some attraction; Galileo would have said the same thing. But why didn’t the moon fall? Maybe it does fall, but we don’t think of it that way, since it falls around the earth! What kind of path then, does it follow? Newton started with the convenient assumption that this path is roughly circular, and calculated how much force would be required to coerce the moon into following such a path, comparing it with the force exerted on the apple. From that intellectual platform he was able to construct a proof of the correctness of the foundations underlying his reasoning—by using them to calculate the length of the month, which he then compared with the observed value, finding the calculated value and the observed one to be in substantial agreement. So the story goes.

After Newton’s return to Cambridge, recognition rapidly followed; he was advanced to the Bachelor’s and Master’s degrees, and in 1669 was elected a Major Fellow of Trinity College—a bit tricky for a Unitarian. Not long afterwards, his mentor Isaac Barrow magnanimously resigned his chair as Lucasian Professor, so that it could be duly bestowed upon Isaac Newton. In 1687 the work that Newton claimed to have begun in the orchard at Woolsthorpe appeared in its mature form as The Mathematical Principles Of Natural Philosophy (known familiarly as The Principia), one of the most influential (and least-read) books ever written.

But why should we treat Newton's story with skepticism? Let us look at some of the facts. Physicist Robert Weinstock points out that Newton never mentioned the subject of gravitation until long after his sojourn on the farm at Woolsthorpe; and that his nemesis Robert Hooke had been on the track of gravitation long before Newton's Principia came off the presses. So there is more to Newton's
Newton The Warrior

In 1672 Newton was elected to The Royal Society Of London. This august body had been established by Charles II in 1662, as a result of his desire to support (and to control), the country’s intellectual establishment. Newton’s first submitted paper was a treatise on light and color, one which had occupied his time for much of the previous eight years. It was this brilliant piece of work that was the occasion for the first of his many blood feuds—this one with Robert Hooke, a brilliant scientist, a member of The Royal Society when it was first founded, and who was at that time its President. Hooke was not a particularly lovable man either; he was devious, envious, vengeful, and given to violent outbursts of anger. It was not long before Newton and Hooke had become embroiled in ugly fights over priority of discovery. The tactics of the former have been examined by historians, and have been unanimously found to be equally devious and vindictive. From this early moment in Newton’s career it became obvious that discovery filled his profoundest psychic needs, and one of those needs was possession: total, exclusive and secret. Hooke retained his post as President of the Royal Society until 1703, but his star declined as Newton’s rose. Ultimately Newton succeeded him as uncontested leader of the herd. Most of Hooke’s papers and instruments disappeared from the storerooms of the Royal Society over the following years. Two buildings designed by him were falsely ascribed to Christopher Wren. One suspects that Newton had done all he could to remove all records of Hooke’s existence; he really seems to have been the original inventor of the Memory Hole. In fact, even twenty years later, at the mere mention of Hooke, Newton seems to have had difficulty retaining his composure.

The same pattern was repeated some years later in the case of John Flamsteed, the Astronomer Royal. Newton’s early work had been based upon Flamsteed’s excellent measurements—measurements that the latter had continued to refine. But with time Newton began to feel that Flamsteed was withholding the results of his observations. Newton would not be put off; so he had himself appointed to the governing body of the Royal Observatory, and tried to force immediate publication of the data. Eventually he even arranged for Flamsteed’s work to be seized and prepared for publication by Flamsteed’s mortal enemy, Edmond Halley. But Flamsteed fought back gallantly, taking the case to court, ultimately winning a court order preventing distribution of the stolen work. Newton became incensed at this, and sought to obtain his revenge by systematically deleting all references to Flamsteed in later editions of The Principia: It was the Memory Hole again! While pondering this matter, it should be borne in mind that Flamsteed was one of the greatest observational astronomers of all time. At the beginning of the 17th century, Tycho’s margin of error had been one degree of arc; Flamsteed’s margin was a mere ten seconds of arc! But no matter, it was fatal to defy Newton.

But the most infamous example of Newtonian bellicosity and deviousness was the famous Duel With Leibniz. Newton had begun his development of the calculus as early as 1664; but he had kept this knowledge secret, so that no one could compete with him. Somewhat later, when the German philosopher and scientist, Gottfried Wilhelm Leibniz announced that he himself had invented the calculus, Newton accused him of plagiarism. A battle royal ensued, and as the row grew, Leibniz made the mistake of naively appealing to the Royal Society to resolve the dispute. Newton, as President of that body, appointed an “impartial” committee to investigate the matter, a committee consisting entirely of Newton’s friends! But not satisfied merely to play with loaded dice, Newton then proceeded to write the committee’s report himself; and afterwards he had the Royal Society publish it, officially accusing Leibnitz of plagiarism. Still unsatisfied, he then wrote an anonymous review of the report in the Royal Society’s own periodical. Following the death of Leibniz, Newton is reported to have declared that he had taken great satisfaction in “breaking Leibniz’s heart.”
These murderous rages did not end after he had retired from Cambridge. In 1696 Newton was appointed Warden of the Royal Mint. The job had been intended as a sinecure, a political plum, but Newton went to work with a grim puritanical enthusiasm that must have appalled some of his contemporaries. Counterfeiting was rife in England at the time, and Newton proceeded to devote hundreds of hours to the “enhanced interrogation” of suspects. Counterfeiting was also considered to be a form of treason; and the punishment for it was hanging. In those enlightened times, it was considered important to be merciful; hence Drawing and Quartering were dispensed with. Simple hanging would suffice.

His biographer Frank Manuel makes the point:

At the Mint he could hurt and kill without doing violence to his scrupulous puritan conscience. The blood of the coiners and clippers nourished him.

The Need For Certainty

The two tests of Newtonian truth were: 1) The Bible, regarded as historical fact, and not metaphorical, and 2) Rigorous mathematical proof. During the same period Newton was engaged in composing a Chronology of the Kingdoms of the World, as well as an exposition of the prophecies of the Old and New Testaments. It is clear that he also felt that he had been divinely chosen to explicate the motions of the heavenly bodies, and to lay down the rules by which the motion of all bodies was determined. It is a short jump from this for him to imagine that he had actually been chosen to explicate the history of the earth, and the ways in which God had intervened in the affairs of mankind. Thus EVERYTHING could be forced into the pattern. In the words of Frank Manuel: 21

To force everything in the heavens and on earth into one rigid, tight frame from which the most minuscule detail would not be allowed to escape free and random was an underlying need of this anxiety-ridden man. And with rare exceptions this fantasy wish was fulfilled during the course of his lifetime. The system was complete in both its physical and historical dimensions. A structuring of the world in so absolutist a manner that every event, the closest and the most remote, fits neatly into an imaginary system has been called a symptom of illness, especially when others refuse to join in the grand obsessive design. It was Newton’s fortune that a large portion of his total system was acceptable to European society as a perfect representation of reality, and his name was attached to the age. That part of the Newtonian system which was related to his puritanical bibliolatry and to his interpretation of prophecy was, of course, rejected by most eighteenth-century intellectuals, and for many years was kept hidden as a shameful weakness in their new god. In our own enlightened age, it is now possible to restore to Newton without prejudice the whole of his unified system of the world, both sacred and profane, physical and historical.

When not engaged in supervising the torture of suspected counterfeiters, Newton occupied his final years living in London, basking in the afterglow of his own fame. It was only seldom that he felt compelled to show “the paw of the lion” (as he once expressed it). The large trunk which he had brought with him in the coach from Cambridge up to London, contained all of his surviving papers; and after his death in 1727 the trunk passed into his niece’s family, where it remained until its contents were put up for auction in 1936, by one of her descendants. Disturbed by this act of impiety, and anxious to preserve as much of the collection as possible from disappearance, the celebrated economist John Maynard Keynes rescued about half of the total, presenting his treasure to Cambridge University in 1942 in
commemoration of the Newton tercentenary. For this event Keynes wrote a celebrated essay, which was read after his death by his brother in the cellar of King’s College, Cambridge, amid the sandbags that had been stacked about as an ineffectual defense against any possible German air-raid.

The Last Of The Magicians

Prior to the time of the Sotheby auction in 1936 no one had ever examined in any detail the contents of that mysterious trunk. During and after the eighteenth century the rationalists of the time had proceeded to re-create Newton in their own image, portraying him as the epitome of “cold and untintured reason”. But instead the contents of Newton’s papers serve to identify him, as Keynes put it, as “the last of the magicians, the last of the Babylonians and Sumerians…”.

But why did Keynes refer to him as a magician? It was because Newton saw the whole universe, together with its contents, as one vast riddle, one that could be read by applying pure reason to certain hermetic clues, which God had hidden about the world for him to find. These clues could be found not only by studying the heavens, and by performing certain alchemical operations, but also in secrets handed down an unbroken “golden chain” of sages tracing their origin to ancient Babylonia. Once Newton had seen that he could read the riddle of the heavens, he imagined that he could go on to read the riddle of predestined, divinely ordained past and future events, as well as the constitution of the elements and the riddle of health and immortality. And it was this quest which occupied most of Newton’s time during the same twenty-five year period that he was Professor at Cambridge, working on his prodigious Principia. These additional writings, esoteric and occult, amount to more than a million words!

For several weeks during every spring and autumn one could find Newton feverishly at work throughout the night in his laboratory at Cambridge, his furnaces roaring, as he performed his secret alchemical experiments. His surviving laboratory records come to more than 100,000 words, even though much of the original material was destroyed in a fire that had consumed his laboratory in 1693. Since the science of chemistry had no existence separate from alchemy during the 17th century, we can safely credit Newton as having been the foremost chemist of his time.

[III] Newton and The New Cosmopolis: How the One Affected the Other. Newton’s unexpected effect upon the new social order

The period after the Restoration in 1660, and the Glorious Revolution of 1688 saw profound changes in the English social order. And Newton woke up in the late 1690s to discover that he had become a culture hero in the eyes of the upper classes of British society, even though his scientific works went largely uncomprehended and unread. The story of how this came to pass contains a lesson for every society, including our own, so I shall tell it.

We can even assign a date to the inauguration of Newton into his new social role: it was that of the death of the chemist Robert Boyle in 1691. In his will Boyle had made provisions for a series of lectures to be given: “for proving the Christian Religion against notorious Infidels…”. Of those chosen to deliver the Boyle lectures, the two most persuasive were Richard Bentley and Samuel Clarke, both ministers of the Church Of England, and both fairly well-versed in the Newtonian world-view. These lectures
provided their listeners and subsequent readers with the first clear formulation of what became known as the Newtonian natural philosophy. It is fair to say that, when combined with more technical commentaries by Newton’s disciples, these lectures laid the foundations of a world-view that had enormous impact on Western thought, not only during the Eighteenth Century, but also in our own time. In short, the Boyle lectures were pivotal. In the words of the historian Margaret Jacob:

Their Boyle lectures reveal that they consciously rejected alternative natural philosophies in favour of the Newtonian system. What is more they pitted this ‘new and invincible’ system against the mechanical philosophy of Hobbes, the fatalism of Epicurus and the remnants of Aristotelianism. They did so not simply because they disagreed with these explanations of how the universe worked, but because they also and primarily saw these philosophies as profound threats to the social, political and religious order—the basis they imagined for the security of church and state. The Newtonian model provided for these churchmen a foundation upon which that order might rest secure.

This habit on the part of churchmen of linking natural philosophy with social ideology grew out of the civil wars and Interregnum and can be traced throughout the Restoration. The Boyle lecturers were the direct descendants of the churchmen and virtuosi who forged this tradition. The proper study of nature became for them the key to understanding and reforming the social order....

This is utterly astonishing! How could there be any possible connection between the pious cogitations of these Anglican divines on the one hand and the hermetic lucubrations of this secretive and ferocious alchemist, mathematician and physicist—and crypto-Unitarian?

Let me attempt an answer. Since the earliest civilizations there has always existed a priestly caste, whose duty it has been to justify the stability of the polis by forming a ritual connection with the cosmos. They were the creators of the social Myth, of the cosmopolis. In the 1690s the priests, in order to survive, found themselves forced to re-discover their ancient calling. Men like Bentley and Clarke had been dismayed at the state to which their church had fallen since the Glorious Revolution; further, they had been appalled at the social instability that had marked the recent history of their country; last, and frankly, they had regretted everything that had taken place since the year 1642. (This phenomenon should not astonish an American living today, at a time when the corridors of power are packed with bizarre individuals who would love to undo everything that has taken place since 1932, or possibly even 1864). But in England many members of the upper classes had shared the alarm of Bentley and Clarke, and felt the need for stability at almost any cost.

Newton’s science differed from that of the Hobbeseans and Epicureans in one important particular: gravitation. To the mind of a Bentley or a Clarke, gravitation guaranteed the stability of the solar system; for them the sun would always rise on the morrow, courtesy of God’s inverse-square law. Moreover, it had long been the custom for natural philosophers to look to the book of nature for news of God’s plan for the world. Thus the authors of the Boyle lectures held up gravitation, as well as the seeming regularity and stability of planetary motion, as the model for human society. To Clarke, for example, it is essential for the preservation of social order that the individual must:
...attend the duties of that particular station or condition of life, whatsoever it be, wherein providence has at present placed him, with diligence and contentment, without being either uneasy or discontented, that others are placed by providence in different or superior stations in the world; or so extremely and unreasonably solicitous to change his state for the future, as thereby to neglect his present duty.

This is how the solar system came to function as a divinely provided metaphor for the social order. And in this way the British class system has survived through the rest of the second millennium. A salient feature of this cozy arrangement cannot be allowed to go unremarked: God is to the universe as a king is to his kingdom, as a husband to his wife, as a father to his children. Unto everyone his/her place, and Newton’s solar system is the model. “And you, you can be the planet Mars!”

One can readily see that the motivation for this interest in stability on the part of the members of the Establishment was not totally abstract or disinterested; it was propelled by cold, white-knuckled fear. The Non-conformist Sectarians had left an indelible impression upon the minds of the landed gentry and their clerical relatives. They feared that their comfortable usages and privileges would dissolve in chaos. As mentioned earlier, even The Royal Society made serious attempts at language reform, spearheaded by Thomas Sprat, who was its Historian. The object of this reform was to reduce language to a one-to-one correspondence with “real” objects. There would be only “so many things in the same number of words”, so as to make virtually impossible any ambiguity and nuance. The purpose of the reform was the abolition of Metaphors, which were seen as conducive to poetry, which was in turn recognized as a “gateway drug” to the dread Enthusiasm.

It is only fair to say that the Newtonian Cosmopolis, crafted by Bentley, Clarke and others, was not received with uniformly positive emotions throughout England. In particular, radical sectarians who had received their intellectual and spiritual formation from the Civil War had evolved a correspondingly radical view of the universe. For many of them it was still true that the Universe is alive. For the creators of the Newtonian Cosmopolis the universe was mostly void, and inhabited almost entirely by inert matter; in such a scheme life is a severely localized phenomenon, almost a trivial exception to the rule. The bodies of the universe being inert, are mindless, and capable of being moved only from without. This idea is in harmony with Newton’s First Law: The Law Of Inertia, which states that a body at rest remains at rest, unless acted on by an external force.

Curiously, the radical sectarians saw matters in a very different light. Here is an interpretation of their thinking, one which, it is important for me to point out, was deeply alchemical in character:

(1) Reality is dialectical in nature: that is, nothing is stable. Things do not have fixed properties. All is in a state of flux. Things can change into their opposites. Opposites are not static. Things change as a result of internal contradictions. Thus,

(2) The fundamental cause for change is internal; things change because of themselves, as much as by external intervention.

It is easy to bring up the objection that Newton’s laws provide an adequate description for a wide range of phenomena, and that they still suffice for the highly accurate placement of space vehicles at the farthest reaches of the solar system. But to this objection a radical sectarian would say: “Yes, but this is irrelevant. What we are objecting to, is your metaphor. As we understand it, you are
using Newton’s laws of motion, applicable to inert objects, as a metaphor of the laws of society. But they aren’t. The Newtonian metaphor is a kind of code phrase, of the kind with which we are painfully familiar in the political America of the late 20th Century: it says one thing to the brain’s rational faculty, and quite another thing to the Unconscious.” Why is this a code phrase? Because, although it sounds scientifically correct, it was in fact employed to justify the notion that the human mass, (i.e., “the lower orders”), like the physical mass, is to be deprived of the capacity for independent action, and subjected to the wishes of their betters. But the lower classes knew “for whom the bell curves.” In the words of the philosopher, Stephen Toulmin:33

What strikes us as a matter of basic physics was, in their eyes, all of a piece with attempts to re-impose the inequitable order of society from which they had escaped in the 1640s.

From an examination of the words of Samuel Clarke (previous page), we can see that the radicals were only too correct.34

The Effects Of The Social Order (the reaction force) Upon Newton

We have already seen that Newton’s religious beliefs (35) were unorthodox to the point of being downright idiosyncratic. These beliefs, if publicly known, would have been more than enough to transform him into a social leper, and send him back to Woolsthorpe in disgrace. But as time passed and Newton became a public figure, his written views on certain sensitive subjects underwent a very curious transformation.

For example, we have seen that Newton was actually a practicing alchemist throughout his entire scientific career; as a young man, he had even been interested in astrology and psychic phenomena. His hermetic researches spanned most of the Restoration period, until the eve of his departure from Cambridge, more than thirty years later. They even persisted during a time when “Enthusiasm” was despised in official circles, especially those in which Newton found himself, such as The Royal Society. “Enthusiasm” was considered to be worse than a disease of the dangerous under-classes; in a Calvinistic world, it was even a form of moral turpitude.

Furthermore the science of alchemy is based intrinsically upon dialectical reasoning, in contrast with the customary Aristotelian logic. In alchemy things change because of themselves—they even change into their opposites, since they contain those opposites in the first place. In the tightly-wrapped world of Newtonian mechanics, and of the British Establishment, all activity is produced from Outside, either from God, or from “His” deputies, the Ruling Classes. Matter is passive, obedient. So Newton was treading on dangerous ground.

In a letter of 25 January 1676, to Henry Oldenburg, then secretary of The Royal Society, Newton wrote these alchemical, even poetic words:

For nature is a perpetual circulatory worker, generating fluids out of solids, and solids out of fluids, fixed things out of volatile, & volatile out of fixed, subtile out of gross, & gross out of subtile, Some things to ascend and make the upper terrestrial juices, Rivers and Atmosphere; and by consequence others to descend for a requitall to the former. And as the Earth, so perhaps may the Sun imbibe this spirit copiously, to conserve his Shineing, & keep the planets from recedeing further from him. And they that will, may also suppose, that this Spirit affords or carries with it
thither the solariel fewell and materiall Principle of Light; And that the vast Aethereall Spaces between us, & the stars are for a sufficient repository for this food of the Sunn & planets.

Some of Newton’s rough drafts, later deleted, are particularly telling. In one of the early editions of the Opticks, according to David Kubrin, Newton briefly asserted that “We cannot say that all nature is not alive.” In another unpublished draft he wrote: “since all matter duly formed is attended by signs of life, those laws of motion arising from life or will may be of universal extent.”

Now compare with the 31st Query to the Opticks (4th ed.), 1730, published posthumously, in which Newton had moved to a position that would delight the heart of the most analytically retentive materialist, producing the following words:

It seems probable to me that God in the beginning formed matter into solid, massy, hard, impenetrable, movable particles, of such sizes and figures, and with such other properties and in such proportion to space as most conduced to the end for which He formed them…. And therefore, that nature may be lasting, the changes of corporeal things are to be placed only in the various separations and new associations and motions of these permanent particles.

It might be argued that the Great Man did, after all, have the right to change his mind. But the same curious phenomenon can also be observed in Newton’s attitude toward the subject of cosmogony, the theory of how the world was created and developed over time. His interest in the subject had been intense, inspiring works by his most gifted pupils. In time, however, the concept of cosmogony came to the attention of the very same churchmen who had first anointed Newtonianism as the invincible guarantor of social stability. From that point on, the argument took the following interesting course: if the world had changed over time, and if it were still changing (i.e., if geological changes were still occurring), then the world wasn’t really stable, was it? If the world were, by Divine fiat, in a state of flux, of evolution, and if the world were indeed the model for society, then by Divine fiat, society must be likewise variable. Obviously this must not be true (or if true, it must not become widely known)! Thus it became necessary for the clergy to condemn cosmogony as contrary to the design of the Creator. Was it by the purest coincidence that shortly thereafter, in 1706, Newton condemned, in the Latin edition of his Opticks, any speculation of how the world had developed in time?

A possible explanation for this self-censorship on Newton’s part can be found by examining the events surrounding the Glorious Revolution of 1688. The ensuing unrest rekindled the fire of sectarian Enthusiasm, which went on to smolder for decades afterwards. In the mid-1690s an Irish hermeticist named John Toland, who was studying in Edinburgh with Newton’s disciple David Gregory, made the damning observation that the Newtonianism, which was being used to justify the religious and political Establishment in England, was actually more in harmony with the idea that matter is alive and sensate. After all, were there not attractive and repulsive forces everywhere? Thus Toland argued:

All these depend on a link on one another so their Matter (to speak in the usual language) is mutually resolv’d into each other; for Earth and Water, and Air, and Fire, are not only closely blended and united, but likewise interchangeably transform’d in a perpetual Revolution; Earth becoming Water, Water Air, Air Ether, and so back again in Mixtures without End or Number.
And behold, it came to pass, (quite by coincidence of course!) that in the year 1704 Newton’s disciple and spokesman Samuel Clarke, singled out the ideas of Toland as being particularly obnoxious to true religion and “right reason”, while Newton made haste to cover his tracks, as best he might, in the 31st Query to his *Opticks*, in the manner described above.

It was only after more than two centuries, that anyone was allowed to view the secrets concealed by “that prism and silent face”. The revelation of the contents of The Box destroyed forever the myth of the patron saint of the rationalists. By that time Newton, the crypto-Unitarian, was safely buried in that stronghold of Trinitarianism: Westminster Abbey. Such are the ironies of history.

**John Locke: (1632-1704) Newton's Only Close Friend.**

John Locke's political philosophy had a great deal of influence upon the minds of the Framers of the U. S. Constitution. Therefore it is of interest for us to see what this man, whose ideas were also harmonious with those of Isaac Newton, had to say about politics, since for better or worse, we have inherited from Locke most of the ideas of private property and the environment that have currency at this time, more than 200 years later. It might be said that American legal theory on these topics represents the thinking of the finest minds of the 17th and 18th centuries, focused upon the human condition, as they then perceived it. It might be further observed that this is not an unmixed blessing.

In the second of his two Treatises Of Government. Locke observed that "The negation of nature is the way toward happiness." .."that people must become effectively emancipated from the bonds of nature." And, "...land that is left wholly to nature...is called, as indeed it is, waste."

He who appropriates land to himself by his labour, does not lessen, but increases the common stock of mankind. For the provisions serving to the support of human life, produced by one acre of inclosed and cultivated land, are... ten times more than those which are yielded by an acre of land, of an equal richness lying waste in common. And therefore he that encloses land and has a greater plenty of the conveniences of life from ten acres than he could have had from a hundred left to nature, may truly be said to give ninety acres to mankind.

Thus, the essential argument of Locke is that Nature is in a state of chaos until humans come along to order it. This position is exactly antipodean to that of those of us who have learned to think of the world as an ecosystem. Therefore it is possible to understand the massive frustration suffered by those of us who have an ecological vision, at the hands of American jurists who are trapped in the baroque legal universe of John Locke.

**The Essentials of the Newtonian Cosmopolis**

It is useful at this point to summarize the essential points in the legacy of attitudes— the notions which were thought of as “standing to reason” in England, after the Boyle lecturers had finished their handiwork. These notions constitute what Stephen Toulmin aptly describes as the original framework of Modernity. As the decades passed, some of these points were dropped, and others added, but below are the essential features of the Newtonian Cosmopolis, and the chief girder of this structure is the Cartesian Dichotomy— that between mind and matter:

- Human actions or experiences were mental, performed willingly and freely, conforming to Reason. The “human” thing about humanity is its capacity for rational thought or action.
• Physical phenomena on the other hand, involved brute matter, and were purely material: they were thought to be mechanical, repetitive and predictable effects of causes. Matter itself was passive and inert. Matter does not think. Rationality and causality follow different rules.

Other "self-evident truths" were:
• Nature is governed by fixed laws set up at the creation.
• At the Beginning, God combined natural objects into stable and hierarchical systems of “higher” and “lower” things. Motion in nature, like action in society, flows downward, from "higher" creatures to "lower" ones.
• Freedom versus causality, mind versus matter, active versus passive, creative versus repetitive, Humanity versus Nature: these are all variations on the Cartesian theme.
• Human beings can establish stable systems in society, like the physical systems in nature.
• Humans live mixed lives, part rational and part causal: as creatures of Reason, their lives are intellectual or spiritual, as creatures of Emotion, they are bodily or carnal.
• Emotion typically frustrates and distorts the work of Reason; so the human reason is to be trusted and encouraged, while the emotions are to be distrusted and restrained.

As we can see, the Newtonian Cosmopolis is far from identical with what we have come to recognize as the mental structure of the Modern World, so familiar to us from science magazines and “general science” courses; neither is it the same as the "Newtonian-Cartesian paradigm," discussed in works written in the 80's by such authors as Fritjof Capra and Morris Berman. But the Cosmopolis of Isaac Newton represented a giant step in the direction of Modernity. For the next step, though, we must “cross the narrow seas” to France.

Notes to Chapter Six:
(2) Having been born prematurely, Isaac was tiny, and was not expected to live. It was said that at birth he could have been fitted comfortably into a quart jar. His father died before Isaac was born, and his subsequent search for a father was to be an important task for him.
(4) Hill, Christopher, The World Turned Upside Down, Viking, NY, 1972. The tale is a fascinating one: an illustration of the extent to which the ruling classes impose their view of reality upon everyone else; and of the existence of the Enduring Counter-culture, which re-emerges whenever the opportunity presents itself. Every word Hill wrote vindicates the view taken by Friedrich Heer in The Intellectual History of Europe, Vol. II, page ix. See also, Berman, Morris, Coming To Our Senses, Chapter 3, The Body Of History, Bantam, NY 1990.
(5) Like today's Pentacositals.
(7) See Hill, Christopher, The World Turned Upside Down, Some of these sects have persisted, even unto the present time. An obvious example is the Quakers, who have established a formidable and respected presence in our own time. But the present-day Quakers present themselves in a much tamer fashion than did the original followers of George Fox. The celebrated scholar, E.P. Thompson, while doing research for his book on William Blake, discovered by accident that the Muggletonians had actually persisted until the 1940’s. To learn more about this fascinating subject, see Witness Against The Beast, by E.P. Thompson, The New Press, NY, 1993.
(8) On one occasion when traveling in England, I happened to meet an elderly woman on the train from Yeovil Junction to Weymouth, on the Channel. She proudly wore a costume appropriate to the time of the English Civil War, (one she had woven herself), and she was en route to a re-enactment of the Battle Of Weymouth, which had taken place during that war. She had apparently read all of the underground history of those marvelous, turbulent times.

(9) Friedrich Heer, in his superlative *The Intellectual History Of Europe*, repeatedly stresses this fascinating point; that ideas outlive massacres. (See pages x, 101 et seq.)

(10) The hierarchy of the Church of England comprised fanatical proponents of the idea of the Divine Right Of Kings. William on the other hand, understood that his rights had their origin in Parliament.


(12) Manuel, Frank, *Portrait Of Isaac Newton*, Ch. 3.

(13) After the Restoration of the Stuart Monarchy (in the person of Charles II), the Anglican Church was re-established as the Church of England, under the Clarendon Codes. Since Oxford and Cambridge functioned mainly as seminaries for ministers, a few of the more religiously unorthodox scholars were purged from the University. But the matter was sufficiently volatile that a policy of “Don’t ask, don’t tell” was the order of the day. In 1689 an Act Of Toleration was passed, followed by a “Broad-Church compromise”. But there were dangerous moments in Newton’s career. When he was made a Fellow at Cambridge, and given the Lucasian Chair, it was normally required that this honor would entail his taking Holy Orders as a minister of the Church Of England. However, in his case an exemption was made. One thing was clear, however. If it had become publicly known that Newton was not a Trinitarian, he would have lost all employment, and would have become banished from “polite company”. His probable fate would have been an ignominious exile at his mother’s farm at Woolsthorpe. Shortly after Newton left Cambridge, his successor William Whiston got into exactly the same situation; and that was the end of his career.

(14) Berman, Morris, *The Reinchantment Of The World*, p.110


(16) I can’t help mentioning that, for most young people, the aphrodisiacal function of the moon would have far outweighed its astronomical significance—but not for Newton, who apparently died a virgin.

(17) Given the acceleration of the apple due to gravity at the surface of the earth, the inverse-square law of gravity, and the earth-moon distance, it is indeed possible to calculate the length of the month!


(19) One degree of arc is an angle equal to twice the diameter of a five-cent piece held at arm’s length: not a very impressive standard of accuracy.

(20) He had announced his discovery by a cipher.


(23) The box’s contents were briefly examined in the18th century by an Anglican bishop, who slammed the lid shut in horror—Newton? Buried in Westminster Abbey? A Unitarian? What a scandal! In the 19th century the physicist Sir David Brewster, desirous of writing Newton’s biography, also had a “go” at the box, and resolved that no word of his idol’s magical and alchemical contents would be allowed to pervert the minds of aspiring scientists. Only in the 20th century did the truth come out.

(24) Among other things, Newton was obsessed with the notion that the secret truths of the Universe were hidden in the dimensions of the Great Pyramid, of Solomon’s Temple, and in the Book Of Kings and the Book Of Revelations. Keynes stresses the point that : “All of Newton’s unpublished works on esoteric and theological matters are marked by careful learning, accurate method and extreme sobriety
of statement”.

(25) This is a gross oversimplification, for it covers a process that was really carried out in a far more brutal, punitive manner. Those members of the Long Parliament who had voted for the execution of Charles I, and had been foolish enough to remain in England at the accession of his son to the throne, were duly put to death. The body of Oliver Cromwell, leader of the Parliamentarians, was exhumed and beheaded, the head being placed on a pike. Attendance at Anglican church services again became compulsory, as was tithing. It was only after 1689 and the Toleration Act, that church attendance became optional—having the result of leaving the churches nearly empty. But even then religious Non-conformists, the heirs and heiresses of the Radical Sectarians of the 1640’s and 50’s, were persecuted—many of them being “transported” to Australia. To this day, some Australians refer to themselves proudly as “Diggers”.


(27) To the Epicurean (=mechanistic) mind, (such as Gassendi’s), or to Hobbes’, there is only matter and motion. Matter interacts only by collision.

(28) This way of thought was accepted across the entire breadth of the politico-religious spectrum. Consider the words of Gerrard Winstanley, leader of the Diggers, and prominent radical of the 1640’s: “To know the secrets of nature is to know the works of God...and indeed if you would know spiritual things, it is to know how the spirit or power of wisdom and life, causing motion or growth, dwells within and governs both the several bodies of the stars and planets in the heavens above; and the several bodies of the earth below, as grass, plants, fishes, beasts, birds and mankind.”

(29) Margaret Jacob, The Church and the Formulation of the Newtonian World-View.

(30) It is impossible not to notice that, during the 17th century a major stylistic change had occurred in the English language. Compare the words of Shakespeare, who died in 1616, with the crabbed, shriveled prose of Newton later in his career. See The Seventeenth Century Background, by Basil Willey, Doubleday Anchor Books, NY.

(31) The Newtonian Cosmopolis is itself a Metaphor, a Map of reality. But for the Newtonians it was the territory. Read on; there will be more about this later.

(32) This is Taoist thinking, too—the principle of yin and yang.


(34) If this notion seems indigestible, we could remember that the ideas of Descartes were accepted in English society, and recognize that the upper class belief could be expressed as subjecting the slothful and vicious human stuff (res extensa) to the creative spirit (res cogitans) of their Betters.

(35) J. M. Keynes considered the victory of the Trinitarians in England after 1660 to be as extraordinary as was their victory under St. Athanasius at Nicea, in 325 AD. The story of Nicea is a very interesting one, also; it is treated in a most readable, accessible manner by Karen Armstrong in: A History Of God, Ballentine Books, NY, 1994.

(36) After the Restoration and the subsequent founding of the Royal Society, its program, in the words of its Historian, Thomas Sprat, was to ensure that the study of natural philosophy would reinforce respect for law and order, and to discourage an tendency to tamper with the basic institutions of society.

(37) Jacob, M. C. John Toland and the Newtonian Ideology, pp 310-314.


(39) Toulmin, Stephen, Cosmopolis, Univ. of Chicago Press, 1990. There is a complete, excellent treatment of these “timbers” on pp. 107-121. This is a great book!

(40) See The Turning Point and The Tao Of Physics by Fritjof Capra, as well as TROTW, by Morris Berman. To accuse Descartes and Newton of being responsible for the Modern World is, as you will probably agree, unfair. Personally, I don’t think blame is an appropriate response.
CHAPTER SEVEN
VICTOR FRANKENSTEIN’S MONSTER

The truth of art consists in its power to break the monopoly which those in power exercise by defining what is real. The supreme merit of art is that it contradicts the version of reality that obtains in social and economic life.

Denis Donaghue.

In spite of the help that some celebrated pedants have brought to the natural stupidity of man, I would never have believed that our country could march with such velocity along the way of progress. This world has acquired a thick layer of vulgarity that gives the contempt of a man of the spirit all the violence of a passion.

Charles Baudelaire

Herein we propose to follow a thread that leads from the death of Newton to the philosophical, literary and artistic scene as it was at the end of World War I. It is impossible to do justice to 200 years of history in the scope of a single chapter; but this was a time when the Myth of Modern Civilization was taking form. So, follow that thread we must. We shall to confine ourselves rigorously to certain themes relevant to the changing mental landscape of the time in Europe and North America--to nibble at those parts most germane to our themes of mythology, to stress the essential mindlessness of Modern Civilization, and the manner in which it molds the minds of its inmates. Our primary topics are:

• How Newton's Myth underwent a sea-change as it crossed the Channel to Mainland Europe.
• How Newtonianism gave rise to the idea of Progress, a new ingredient added to the Myth. This package has been called: The Enlightenment.
• How we can understand the rise and fall of nation-states, and even of civilizations, in terms of simple concepts of Thermodynamics.
• How Newton's theory of light was overthrown, in what is arguably the most important experiment in the history of science--certainly an event of tremendous importance.
• The struggle between the rationalists and the empiricists; why did the former elect to ignore the phenomenon of hypnotism?
• How artists, composers and poets reacted against the Newtonian Cosmopolis.
• The Great War: its causes and its impact on Modern Civilization.

The Great Sea Change

We have seen that the Newtonian Cosmopolis was the subject of a kind of self-justifying Myth, having its origins in the English politico-religious Establishment. It was basically a story-line, concocted for the purpose of insuring the stability of the English class-structure after the collapse of the medieval world-view. This story-line captured the mind of Isaac Newton himself. By the time Newton died, his Myth, his Cosmopolis had become a software program for navigating through the humdrum of daily life, without asking any embarrassing questions. But across the
Channel there was another kind of nation-state, with its own Cosmopolis: France. In the 17th century Cardinal Richelieu had bequeathed to his countrymen a powerful, centralized monarchy, one that went on to exercise intellectual hegemony over much of continental Europe, even into the 19th Century. However, decades of despotism, carried out in the name of the Divine Right Of Kings had produced a tight censorship over art, drama, poetry and music, one that had a paralyzing effect upon the intellect of that country. After the end of the sixty-five year reign of Louis XIV in 1715, people began to speak up, furtively at first, in coffee houses--institutions which were multiplying wildly, and which were correctly regarded as dens of subversion and drugs (namely, caffeine). Books and pamphlets were beginning to appear, whose authors wisely published under assumed names. And of these authors, the most famous, was François Marie Arouet, who wrote under the pen-name of Voltaire. It was in the 1720's that Voltaire made a pilgrimage to London, specifically to visit Isaac Newton, and to ascertain the degree to which the Old Man's view was correct. Since early in the career of Newton there had been a split between him and the Cartesians over the proper explanation of the motions of the solar system. By the time of Voltaire's visit, some of the French had come to suspect that Descartes' view of the solar system had been wrong. But others, in their nationalistic pride, could not easily admit this; therefore a fact-finding expedition was in order. Hence Voltaire's mission to London, from which he returned to France as a convert to Newtonianism. "All you have to do is to divide the force by the mass, in order to get the acceleration," was all he had to say. Newtonianism promptly ignited a firestorm of interest in the French intellectual underground. However, this time it was Newtonianism with a difference, for its program did not include support for the Church and the Monarchy. It had even been said that progress would not be made until the last king had been strangled with the entrails of the last priest. (It was Denis Diderot who said this). Truly, the French Newtonians were there to destroy Cosmopolis, not to praise it; and there would be no Samuel Clarkes and Richard Bentley's on hand to save it from its fate. It was the French philosophers who had removed God, the absentee Cartesian monarch, from his throne on the rim of the world; and after the French Revolution of 1789, the little wheels of the human being and the automatism of the beasts would be left to tick over on their own, without Divine intervention.

By the time of Napoleon's empire, (1799-1815) the mechanistic world-view, the metaphor of the clockwork universe, had become entrenched as the dominant paradigm in France, from whence it swiftly spread to the rest of Europe. Pierre Simon de Laplace, the leading mathematician and astronomer of Napoleon’s time, was able to claim that, given enough information, we could predict the entire future--and for that matter, retrodict the past--of every particle in the universe, including those that comprise people. This myth, of a completely deterministic, mechanical universe, (a radical mutation of the Newtonian Paradigm), became incredibly contagious. In its earlier, Newtonian-Lockeian version, it had had a profound influence upon the framers of the American Constitution, creating a machine for governing, its checks and balances ticking like the parts of a clock. Here in the United States it can be claimed that we live in the first mechanically-run country in history—the mind boggles at the intellectual daring of that idea, and its fragility, (especially now, at this writing, during the reign of Mr. Obama).

**What Seemed to be Self-Evident at the End of the Eighteenth Century**

As a result of the efforts of French philosophers and scientists, certain mutations had occurred in
the structure of the Newtonian Cosmopolis, giving it a new shape. Of particular interest to us again are the mythical ingredients—the unexamined assumptions, the things that “stood to reason” at the turn of the century.

- The Cartesian Theater. Following Descartes it became convenient to think of what is “together” in the Mind as having been brought together in a single place in the Brain—a place where the CinemaScope screen is located. And “you” are a tiny homunculus, who watches and directs the show on that screen.
- The Real World is what "you" are seeing in the Theater. The Theater Inside gives a completely faithful replica of the World Outside.
- Nothing Is In The Mind That Was Not Previously In The Senses. Thinking is merely the act of comparing new pictures with old ones that we have stored in our brains.
- The events in the Universe are like those which are seen by an omniscient Observer, looking in at the world from the outside.
- The world is constructed of atoms, carrying fixed properties, independent of the methods chosen to measure them. This is called "radical atomism."
- The Mirror Of Nature. A valid scientific theory is a faithful replica of nature. We "speak" the language of nature. Nature will not let us down.

**Le Progrès: A Dynamic Addition To The Myth Of Modern Civilization.**

During two muggy July days in Paris in the year 1750, a nervous young man named A. R. J. Turgot spoke at the Sorbonne, delivering lectures which he entitled: Discourses On Universal History. In reality, the topic was a concept he called Progress. Turgot conceived Universal History as the progress of the human race as it advanced, steadily though slowly, through alternating periods of calm and disturbance towards greater and greater perfection. Six years later, Voltaire was to write his Age Of Louis XIV, in which he claimed that wars and religions have been the great obstacles to the “progress” of humanity; and if these were to be abolished, together with the prejudices that engender them, the world would rapidly improve. Although the notion of “universal progress” is not something that can be verified in a laboratory, (and indeed, it is almost certainly delusionary), it became a vital part of the Great Myth of Modern Civilization. It even lent to Civilization the appearance of a certain rightness and inevitability. It is both of these last items that we need to call into question.

In retrospect, the notion of Progress seems to have played the same role in the subjugation of the indigenous peoples by Western Civilization that the slogan “God wills it” played in the Crusades: a magic word used to justify wholesale slaughter. Indeed, it is impossible to exaggerate the importance of the myth of Progress as the software of Euro-American imperialism—attempting to justify the deaths of perhaps 50,000,000 indigenous people in Africa and the Americas. And it has continued to play a vital religious role in the structure of Modernism, the Modern Cosmopolis. Of course, we have been hearing rather less of this mantra of late --and for good reason.

**The Thermodynamics of Greed**

After the Treaty of Westphalia in 1648 signaled the end of the 30 years’ War, the first two powerful nation-states that emerged were England and France. During the following 165 years it
is a documented fact that these two nations were almost continually at each other’s throats. The warfare was not a result of religious misunderstanding as Voltaire had claimed; instead it was a question of world dominion. It must be pointed out that in human affairs, Religion and Monarchy are secondary; Power and Control are primary. In the second half of the 18th century England had been the beneficiary of that major technological breakthrough which we call the Industrial Revolution; and became for a long while the most powerful nation in the world. England's rise was ultimately the result of the invention of an improved steam engine by the Scottish engineer, James Watt, making it possible to mine coal at depths below the water table. It was the Industrial Revolution, combined with an extensive colonial system as a source of raw materials, which made it possible for The British Empire to dominate the globe for more than 150 years. What was not apparent, was that the Empire itself was operating according to the same Thermodynamic laws as Watt's Steam Engine.

Napoleon's defeat in 1815 caused a great deal of soul-searching on the part of a disconsolate young French officer, Nicolas Sadi Carnot. Carnot realized that England had won as a result of its superior industrial power--a power that in turn rested upon mastery of the steam engine. Therefore he set himself to the task of understanding the basic principle of the heat engine, of which the steam engine is but one example. When looked at from the proper angle, the heat engine is quite simple; and Carnot was able to formulate its basic law without even understanding that heat is really a form of energy! His results were quite revolutionary, and in a short period of time he was able to invent the essentials of the science of thermodynamics. What Carnot had discovered was that all heat engines are basically the same. Any system which takes in fuel and does work, must function in accord with the Carnot paradigm: steamships and autos, as well as houseflies and humans, cities and nation-states and even stars—they, and we also, partake to some extent of the nature of the humble heat engine. Carnot started by using a simple analogy: that of water flowing through a mill. Since this line of thought is such a simple one, let us follow it, and see where it leads us. To operate a water mill, it is necessary for some water to start out at a higher level in the mill-pond and fall down, through the mill race, in the process giving its energy to a wheel. As the mill wheel turns, it thereby does mechanical work, while the water finally ends up below the mill, unable to do any further work—at least at that particular mill.

Carnot's argument took a straight path, using the following analogies:

\[
\text{water} \leftrightarrow \text{heat} \\
\text{height} \leftrightarrow \text{temperature}
\]

All heat engines accept heat at a higher temperature, use the heat to do work, and then reject heat at a lower temperature. The only difference between a heat engine and a water mill is that a considerable amount of heat is transferred in the process. Where does the heat go? Into mechanical work. Think of the exhaust from your automobile; this is the final, rejected energy from the gasoline that has been burned. The exhaust temperature is simply not high enough for it to produce any further useful work, and so it is mostly wasted. In fact, most of the energy in the gasoline goes to waste—around 90%.

Now that we understand the principle of the heat engine, we are in a position to apply it to ourselves. Let us start with an agrarian civilization, such as Ur, the Anasazi, or any of the Mayan
cities. These were instruments for providing food for people, (the fuel for the human engine). Plant life lies at the base of the human food chain, and the plants depend upon energy from the sun. Once the population had exhausted its plant resources, the Civilization simply collapsed. Whether or not the proximate cause of this had been a change in climate is irrelevant, since the end-point of the process is always determined by the amount of available fuel. This understood, we are now in a position to understand what had happened to Europe after the beginning of the 14th century; it was the same thing all over again, but on a larger scale. But three events had intervened, to keep Europe from total disaster.

• First, in 1348 came the Black Death, which cut back the population by one-third.
• Second, came the "discovery" of the New World, supplying a kind of dumping ground for surplus people, as well as a source of raw material.
• But the third event had the most powerful and lasting effect of all: the vanishing of the forests, which drove the Europeans to substitute coal for wood as a fuel.

Before humans were forced to use coal, what the earlier civilizations had used as their own principal "resource" was wood. On the average, the early peoples were not sucking energy from the planet any faster than the sun replaced it. Thereby, for centuries the human race was able to remain more or less in equilibrium with its environment. Occasional transgressions occurred, of course, but they were swiftly punished by collapse and extinction of civilizations. In the year 1297, as a result of widespread deforestation in England, the freemen of Newcastle were licensed by the Crown to burn coal -- coal, which had lain under-ground for millions of years, and which was originally derived from the sun's energy. After that time the use of coal grew exponentially, pushing Civilization farther and farther into the present dilemma--one whereby every year, more and more non-renewable energy must be used, thus driving the remaining energy "resources" to exhaustion. However, there was one more possibility for the nation states of Europe--that of obtaining colonies, and then bleeding them dry of all their "resources." This, of course, is precisely what happened.¹²

By the middle of the 19th century, countries such as Britain and France (the latter, tardily) had established a rickety structure of empire over distant domains on the surface of the planet. So large were Britain's holdings, that until the Second World War it was said that the sun never set upon the 'Union Jack.' France had gobbled up much of North Africa, and one of the very richest prizes, The Congo, had become the private reserve of the King of Belgium. Helpless before the guns of the Europeans, the inhabitants of the colonies were forced under inhuman working conditions, to mine their own lands, for raw materials to supply the insatiable greed of Europe. But after the year 1870, another powerful consumer appeared at the banquet: it was Germany, hungry for its “rightful share” of colonial plunder. Ultimately the instabilities caused by too many hogs feeding at the same trough would produce two horrendous world wars, thus serving to demonstrate the non-viability of the modern Nation State as a system. We shall touch briefly on this subject once more in one of the following sections.

Pursuing this argument to its conclusion, we can see that, hidden in the abstractions of thermodynamics is a death-sentence upon that heat engine called Civilization. Civilizations have an insatiable appetite for raw materials and fuels, which they extract from their surroundings in order to do more or less useful work. With the passage of time, each incremental extraction becomes successively more expensive than the previous one, until breakdown finally occurs. For
that is their destiny. An invariable pattern occurs in the history of the *Collapse of Complex Societies*\textsuperscript{13}: the resources become depleted; a catastrophe occurs, and the surrounding environment gets an opportunity to rebound. But what if the Collapse of last of the Complex Societies is going to be a worldwide affair? At present we can only say that binges cannot go on forever—but any surviving children of ours will be able to tell their children what happened.

Already at the beginning of the 19th century, the intellectual floor joists of the Newtonian Cosmopolis received a rude shaking. Here is the story of how a medical doctor, (who also had deciphered much of the Rosetta Stone), up-ended Isaac Newton and forever changed the way people look at the world.

**The Celebrated Double Slit Experiment of Thomas Young.**

One of the great triumphs of Newton’s career had been his researches in the field of optics. In the course of this work he had arrived at the view that light travels in the form of tiny corpuscles, and after his death and apotheosis this opinion had quickly become ossified into dogma. Following the mythology of his time, it was only natural that light should be made up of tiny particles, since under the prevailing doctrines, reality was to be described in terms of matter and its motion. But in the year 1801 the blow fell, when a London physician named Thomas Young passed sunlight through a prism and selected out a fraction of the beam that was of one color. This light he allowed to pass through a pair of tiny slits, onto a screen. What he saw on the screen was a series of light and dark bands. Amazingly, the light even reached into regions where no light corpuscles should have been able to penetrate. This effect, easy to describe in the language of wave motion, is called interference.\textsuperscript{14} Worse yet for Newton, it was quickly seen that there is no possible way to explain this effect in terms of corpuscles, a fact that will return to haunt us in later chapters. Therefore, the great Newton must have been wrong after all! We shall soon see why Young’s discovery is probably the most important in the history of science; for after the passage of 200 years we still don’t understand all of its ramifications. The two-slit experiment, in its various ramifications, is a skeleton in the closet of science!

Earlier we spoke of how important a role the Newtonian universe played in justifying the English Cosmopolis. Therefore it is not surprising that Young's experiment did not go unchallenged. None other than Lord Brougham, the future Lord Chancellor of England\textsuperscript{15}, denounced Young in the pages of the prestigious Edinburgh Review, and in effect called him a charlatan! Lord Brougham’s attack went for nought however, for the experiment was easily repeatable, by anyone who owned a prism, and within a few decades the stray phenomena were rounded up, and the wave nature of light propagation was verified—at least to everyone's satisfaction at the time. There was only one remaining question: if light is a kind of wave, what is it that is waving? This topic will be discussed in the next chapter.

**The Warping Of Euclid’s Space And The Decline Of Perspective.**

In a previous chapter we learned that, beginning in the 17th century, France had an immense intellectual impact upon continental Europe. Until the time of the Revolution, the French Style was synonymous with what was called The Classical Tradition. Briefly, what this meant was a ferocious emphasis upon order, perspective and balance; and a singled-minded devotion to
mythological themes, as opposed to situations rooted in the present, whether in literature, art or music. This arrangement was by no means accidental; it was politically expedient. As we have seen, since Plato's time, order in literature, art and music have been seen as essential for the existence of order in the Cosmopolis. In art, various forms of linear perspective were common, and on every canvas it was expected that the human figures would be displayed in a balanced way, preferably in the plane of the canvas. This was the goal of art: “to hold the mirror up to nature”, just as it was in science. (Of course a casual glance at the work of Tintoretto, or El Greco will tell us that genius doesn’t have to play by the rules. But these men weren't painting in France, either).

In the nineteenth century the invention of photography gave the art world quite a shock, for it soon became obvious that the camera does not reproduce spatial relations in the same manner as the eye does. Indeed, the eye plays an active part in creating the picture. This discovery was a revolutionary one, for it destroyed the notion that the eye simply records passively the traces of the incoming light. Among the artists, the significance of this was enormous. But in any Cosmopolis there must be a dictatorship of the eye, the ear, the mind-- manifested in all forms of Art. In 19th century France the artist didn't have to fear that his door would be kicked in by the police, but there were always critics available, who could be counted on to demolish the innovator with a poisonous newspaper review. In early nineteenth-century England the unofficial commissar of art was Sir Joshua Reynolds, who claimed to know what was "fine art," as opposed to mere "crafts." in France the same kind of authority was vested in the l’Académie des Beaux Arts. I might add that in late 20th century America things were not all that different; to control people it is necessary to be able to tell them what to see, and the politicians were more than ready to play the role of censors.

But the winds of revolt were already blowing in Paris in the 1830s, in the famous Bohemian Quarter on the Left Bank of the Seine. The purpose of the revolt was the overthrow of the fundamentals of representational art, in particular the “horizon”, the “vertical”, and linear perspective--which were analogous to tonality and harmony in music. Among early artistic successes were those of Théodore Géricault and Eduard Manet. Impressionism and cubism were soon to follow, and Descartes would never have understood any of it. The direction taken by these artists was that of returning Consciousness to a position of Participant, instead of that of spectator. Since Participation is, from the point of view of Civilization, a treasonous dalliance with the Unconscious Mind, the new paths made in art were quickly seen as dangerous to Public Order.

The Revolt Against Cartesian Music

When the mode of the music changes, the walls of the city shake.

Plato

During the period from 1625 to the early 19th century, music found itself under a similar censorship, and for the same reasons. In Paris the Abbé Mersenne, terrified by threats of cultural disorder, had gone so far as to actually prescribe rules for the composition of music. He wanted to ensure that music would not be able to fulfill its ancient mission of inflaming the passions, producing altered states of consciousness or inciting listeners to riot. Mersenne’s rules, which
formed a framework for Baroque music, ultimately found their way into the standard books on harmony, dating from later in the 17th century. The musical analogue of the painter’s horizon is tonality: a clear sense of the key of the music. It was tonality that came under fire in the nineteenth century—especially from Richard Wagner, who perfected a voluptuous chromaticism that was the epitome of everything Mersenne would have hated. As the ice of tonality began to crack, audiences in symphony halls and opera houses heard sounds the like of which would have been unthinkable before 1859, the year of the premier performance of Wagner's *Tristan und Isolde*. The last decades of the nineteenth and the first decade of the twentieth century were the era of Claude Debussy, Maurice Ravel, Richard Strauss Gustav Mahler, and Igor Stravinsky, men who were busily throwing the old rules out the window. It was also a time of great ballets: first Stravinsky's *The Firebird*, then Ravel's sensuous *Daphnis and Chloe*; but the culmination of this orgy of creativity occurred on the night of May 29, 1913, when Stravinsky’s *Rite Of Spring* received its world premiere in Paris, and the audience erupted in a full-scale riot.

**The Revolt of the Authors and Poets**

By the beginning of the nineteenth century it was impossible not to notice the ugliness and destructiveness that had resulted from the Industrial Revolution—especially in England, which had been its birthplace. Among the writers who revolted against Newtonian rationalism, and created the Romantic Movement, the earliest was William Blake. Other English writers were Byron, Wordsworth and Coleridge, and Mary Wallstonecraft Shelley, who wrote the novel *Frankenstein*, the story which seems to contain the most penetrating psychological insight into the modern predicament. In America there were Walt Whitman, Henry Thoreau, Ralph Waldo Emerson, Edgar Allan Poe and Herman Melville. Melville's *Moby Dick* can be read as another warning of the dire consequences awaiting America as a result of tendencies which at that time were being hailed as beneficial. In Germany there was Goethe, with his towering intellect, whose play: *Faust* displays a keen insight into the dilemma arising from man's grasp for power. France has not only given us writers like Victor Hugo, who did much to pry open the grip of the dead hand of Classicism, but also poets like Mallarmé, Nerval, Baudelaire and Rimbaud. To their credit, the last three of these labored to unleash their imprisoned Unconscious Minds by the consumption of heroic quantities of the meager repertoire of Schedule One substances then available, and spent their lives in a continual state of social disrepute. But all the while they managed to produce glorious poetry. During that time, the members of Modern Civilization who passed for "sane" were preoccupied with steam engines, the telegraph, the telephone, the blessings of dynamite, and of course, machine guns.

**The World Of 19th Century Science**

Civilization's heat engine was turning over more rapidly in the 19th century, producing more and more intricate "islands of order," in the form of human creativity. By some subterranean instinct, people began to realize that there exists a vast inward universe of knowledge and beauty, one that during those years began to unfold exponentially, as more and more support became available to the explorers. It was beginning to look as if Francis Bacon had been right; the cumulative power of science was, for the moment, decisive.

Some of the new discoveries came in the form of elaborations upon earlier work done by Newton
and his colleagues on the Continent. In the 1830's a sophisticated calculation derived from
Newtonian mechanics made it possible for astronomers to discover the planet Neptune. The
public was thrilled by this demonstration of the efficacy of the Newtonian method, for it helped
to validate Modern Civilization, and make people feel comfortable. During the same period an
Irish mathematician, William Rowan Hamilton, discovered an alternative approach to
mechanics, one in which Newton’s laws were reduced to the status of a mere consequence of an
even grander concept. Hamilton's discovery went largely unnoticed, though.

In Germany and Austria, culturally distant from the capitals of the great nation states, scientists
were examining the light spectra emitted by heated substances, comparing them with curious
anomalies in the spectrum of the sun. These anomalies made it possible to compare the spectra of
the sun and of other stars with the spectra of elements on earth; and thereby to learn the
compositions of stars, as well as their rates of rotation. One insight gained, was that the sun is
made of the same stuff that the earth is. It had taken that long for people to find out! Later, in the
first part of the twentieth century this research would be able to upset the Newtonian apple cart
completely, and usher in the quantum theory; but at the time no one dreamed of its potentialities.

A group of mathematicians working independently made a shocking discovery. They found that
there are two distinct, self-consistent varieties of non-Euclidean geometry--that is, geometries
that use postulates different from the Fifth Postulate of Euclid. From this it followed that
Euclid’s geometry may not necessarily describe the universe that we live in--that geometry has a
significance independent of land surveying. Later, in the 20th century, these discoveries and
others would result in calling into question the proposition that we can ever really “hold the
mirror up to nature”. But at the time the world was unable to imagine such potentialities.

**How Rationalism Attempted To Cope With The Human Condition**

Just as at the beginning of the Scientific Revolution, there seemed to be two dramas playing
simultaneously on the stage of history. On the one hand was rationalism, the idea that reason
constitutes a sufficient source of knowledge; and on the other hand, empiricism, a preference for
observation and measurement. By this time, the mechanistic followers of Newton and Laplace,
combining rationalism and empiricism, had amassed a great amount of data and were claiming
the omni-competence of their brand of mythology. But there were empiricists of a more radical
variety, people who were busily exploring continents where the materialists dared not to trespass.

On the one hand, the post-Cartesian mechanists looked upon the human being as a machine, best
understood when completely dissected. This view received ammunition through Virchow’s
studies of cellular biology, and through Pasteur’s work on micro-organisms. It was this work
that introduced the public to the Germ Theory Of Disease. But there was also Claude Bernard, a
pioneer in human physiology, who concentrated upon factors in the cell's environment, which he
called: *le milieu intérieur*--what we would now call the connection between the Immune
System and the realm of mind-body medicine--in effect, the body considered as an ecosystem,
partially under control of the mind.

However, the most influential physiologist of the nineteenth century was the German Hermann
Helmholtz. Once, in 1848, meeting together with three other young scientists, he persuaded them
to join him in swearing a blood oath (!!), to the effect that all their future research efforts would be based upon strict Mechanistic and Newtonian science. Helmholtz’s viewpoint affected the attitudes of thousands of scientists who followed in his footsteps; and among them, years later, there was a young Viennese neurologist named Sigmund Freud.

But There Were Other Mysteries--And Even Today They Remain Unsolved.

It was in the early 1780's that Franz Mesmer, an Austrian, had appeared in Paris. Mesmer had developed a kind of hypnotic technique, one which involved making passes over his subjects, (usually women), waving a large horseshoe magnet. His technique, (called "animal magnetism," and his flair for showmanship, combined to make him an overnight sensation. But whether it was his talent for theatrics, or because certain men of influence objected to his exercising "animal magnetism" upon their wives, he soon made some powerful enemies. In 1784 a Royal Commission was created, chaired by Benjamin Franklin, to investigate Mesmer’s techniques. The Commission found that, to an extent, these techniques worked; they could induce convulsions, relaxation and drowsiness. But when careful trials were performed upon blindfolded patients placed in a trance by one of Mesmer’s assistants, (Mesmer had discreetly left town). The Commission found that nothing had happened. Therefore the Commission upheld the conventional wisdom, concluding like good Cartesians all, that animal magnetism is spurious— that it was nothing but hysteria--“all in their minds”, (and therefore not real); and Mesmer was disgraced.

However, at the same time that the Royal Commission was deliberating, the Marquis de Puységur, who had studied briefly with Mesmer, happened to be using Mesmer’s technique to treat a sick peasant who lived on his estate. While Puységur was making his hypnotic passes, the peasant obligingly fell into a deep trance. But while the peasant was thus entranced, Puységur found that the man could apparently read his (Puységur's) mind. Word of this marvel spread rapidly, and further experiments were performed along the lines of those of Mesmer and Puységur. But the results of this kind of procedure proved disappointing, for “traveling clairvoyance” as in the case of Puységur’s peasant, turned out to be a rare phenomenon, and pressure by rationalists did nothing to help the cause. Despite the initial discouragement, the technique of hypnotism survived, and was being practiced in Paris in the 1870s and 1880s, notably by the famed Jean-Martin Charcot, by Pierre Janet, and by the Nobel-winning, physiologist, Charles Richet. One of the most astonishing discoveries of La Charcoterie, (as this group was waggishly called), was that it is possible for a hypnotist to place his subject in a trance from a distance! This result stands in gross violation of all the doctrines of rationalist philosophy; in Newton's time, gravitation was bad enough, but hypnotism-at- a-distance, that was just too much. What could be done about this?

From the foregoing we can guess that the 19th century was a time when Modern Civilization had settled into a defensive posture, based upon the physics of Newton and the materialism of the architects of the French “Enlightenment”. The exigencies of doctrinal consistency demanded that phenomena found to be detrimental to the stability of the system were to be studiously ignored, whenever "plausible deniability" was not available. Ultimately, when no one was looking, the offending facts would be made to disappear down The Memory Hole. Behold the ongoing struggle: Civilization’s constant effort to update its story line, negating human experience
whenever necessary, and relying on the soothing effect of its myriad distractions to perpetuate the collective trance.

The Great War And Its Aftermath

At the beginning of August 1914 the Great War broke out, turning Europe into a vast charnel house for young men. All the dreams of “Progress” and Modern Civilization were shattered in the senseless slaughter. During the 19th century there had been a great technological breakthrough: the machine gun. Earlier this invention had been used throughout the world against indigenous peoples, and with deadly effect. At the time, Europeans had been able to rationalize this brutality on the grounds that it was in the interests of "Progress" to eradicate "inferior races." But when war broke out in 1914 they began to use it on each other. What followed was a slaughter unparalleled up to that time, even in the history of Europe.

The armistice of 1918 merely produced a twenty-year lull, but it was one during which creative activities such as art, music and literature were changed drastically, to match the feeling of profound disillusionment that the War had produced. What emerged after 1920, (with the exception of Surrealism), was a style that was distinctly “Modernist”: severely abstract, unsentimental, lacking in sensuousness, ostensibly devoid of context.

Also, the general revulsion against war, and the resulting thirst for order, brought to the surface a variation on the style of positivist philosophical thinking that had been embraced at the beginning of the century by some of the most productive scientists of their time. The underlying motivation of the positivists was the search for a kind of knowledge, one that would produce agreement by all parties. In this way it was hoped to purge knowledge of all metaphysical assumptions, including the irrational nationalism that was being blamed for the Great War. (The fools! It was about power.) Positivism was to become more than a hope; it was to become a kind of missionary program, and ultimately even a metaphysical religion in its own right. The positivists were the intellectual descendents of Descartes, and their missionary purpose was to shore up the social structure of Western Civilization with the timber of what was now called: Unified Science. The goal of their project was to make Science the Established Church of Civilization.

The precursor of this group had been Ernst Mach, a Viennese physicist whose intellectual passions were of a strongly empiricist bent. Mach himself had died in 1916, but his writings had already come to the attention of another, even more radical empiricist, William James, Philosopher and Psychologist; and had the support of Jacques Loeb, the physiologist and materialist. In America, a valuable addition to the group was Mach's friend, the publisher Paul Carus, who worked unceasingly to sell the virtues of positivism to the public. The essence of Mach’s vision of science was best expressed by the words of the philosopher Moritz Schlick:

Mach was a physicist, a physiologist, also a psychologist, and his philosophy...arose from the wish to find a principal point of view to which he could cling in any research, one which he would not have to change when going from the field of physics to that of physiology or psychology. Such a firm point of view he reached by going back to what is given before all scientific research, namely, the world of
sensations. Since all our testimony concerning the so-called external world relies only on sensations, Mach held that we can and must take these sensations and complexes of sensations to be the sole content of those testimonies, and therefore that there is no need to assume in addition an unknown reality hidden behind the sensations. With that, the existence of das Ding an sich\textsuperscript{34} is removed as an unjustified and unnecessary assumption. A body, a physical object, is nothing else than a complex, a more or less firm pattern of sensations, i.e., of colors, sounds, sensations of heat, of pressure, etc.

This hard-headed affirmation of John Locke’s famous dictum, (that there is nothing in the mind that is not first in the senses), fired the imagination of several generations of physicists, physiologists and behavioral psychologists, resulting in the publication of an Appeal--“a call to arms” as early as 1912, signed by such luminaries as Albert Einstein\textsuperscript{35}, Sigmund Freud and the great mathematician David Hilbert. The goal of the Appeal, (as it would be called in English), was for scientists and other thinkers to join forces for the purpose of producing a Unified Science—to bring all knowledge under the hegemony of one coherent ironclad Method.

After the end of the Great War a group of young Viennese intellectuals, disillusioned with traditional culture and dreaming of a Modern World full of all kinds of good things, formed a group under the leadership of Moritz Schlick, meeting on Thursday nights at the University of Vienna. This group, called The Vienna Circle, thought of themselves as the Cutting Edge of Modernity, the Shock Troops. They proceeded to tighten the screw of positivism another full turn. The group subscribed to a constricting, rigid sect of rationalism, called “Logical Positivism”\textsuperscript{36}, a doctrine restricting all meaningful discourse to those statements which either describe possible laboratory experiments, or which are derivable from logic. The dream of logical positivism was to create a truly Unified Science, devoid of any contamination by metaphysical notions. But a careful analysis shows that having a theory without metaphysical notions seems to bear a resemblance to lifting one’s self up by one's bootstraps. After all, by what experiment or logical manipulation can we produce the Logical Positivist doctrine in the first place?

The Missionaries Invade The Art Colony And Make Conversions Among The Natives

The problem with the Modern World is that if you are able to create it, somebody still has to try to live in it. But the enthusiasts of the Vienna Circle felt that they could rise to the occasion, for Modernism was their goal, and it seemed to have inevitability written all over it. An important link was forged with a group of architects working in Dessau, Germany, who have since come to be called the Bauhaus group\textsuperscript{37}. We have all seen the Bauhaus style; it is blocky and abstract, built upon very simple geometrical concepts, with little or no attention paid to the requirements of human comfort. By the 1960's it had become kitsch. It is the style common to housing developments\textsuperscript{38}, office buildings, hospitals and resort hotels. It is this style that has become synonymous with Modern Architecture at its worst. Its non-contextuality has led to the remark by some wit that “Bauhaus-style buildings are equally out-of-place anywhere on the globe." Still, if you wish to force a lifestyle upon people, the most effective way is through architecture. One can always turn one's back on a painting, but inside a building, one is trapped. “Bauhaus” equals Civilization, taken to its coercive extreme. While living and working in a Modern building, one
is always receiving the subliminal lesson: "Let me out of here."

**The Self-Evident Facts Reexamined**

- The Cartesian Theater. Profoundly affected by the writings of Ernst Mach, the behaviorist B. F. Skinner held that the only thing we can observe in humans or other animals is their external behavior. Therefore, he held, it is meaningless to speak of the mind, or anything else that cannot be registered externally, predictably, in the laboratory. From that time forward the Cartesian Theater was closed. There was, for him, no Mind.
- The Real World is simply the group experience of the human race. It has no meaning, apart from what our senses, amplified by scientific instruments, tell us.
- Nothing Is In The Mind That Was Not Previously In The Senses. This is a cornerstone of the Materialist structure; it seemed so self-evident that no one examined it seriously. To question this today is pure heresy. (I do more than question it; I deny it).
- As a result of Special Relativity, events in the Universe now depend upon the state of motion of the Observer, in a space-time continuum. But determinism and causality were heading into deep trouble.
- The Mirror Of Nature. One of the principal tenets of classical (pre-quantum) science was that nature is essentially visualizable, and that a one-to-one correspondence can exist between our language and the features of nature. More trouble was ahead for this idea!

**The Canaries In The Mine: A Postscript**

One of the functions historically performed by the artist is that of a sensitive antenna, picking up signals—a distant early warning system similar to the canaries, which miners carried down into the mines, because the birds are sensitive to the presence of minute quantities of poisonous gases. The first ones to sound the alarm were the authors. In the turmoil of the Russian Revolution, Yevgeny Zamyatin composed a dystopian novel, called *We*, which caused great displeasure among the Soviet leaders. After a four-hundred year tradition of Utopias, this, to my knowledge, was one of the very first of the dystopias. In 1929 E. M. Forster wrote a short story, called: *The Machine Stops*. It is a tale about a time in the future, when humans have created a kind of machine that supplies all their wants while they just sit around and think. Naturally, the humans are much the poorer for this; and besides, the machine ultimately breaks down, leaving the humans helpless. Forster’s story was followed by the publication of Aldous Huxley’s *Brave New World*, written in 1931. Huxley’s dystopia is one in which happiness and contentment are socially and biologically engineered. The Machine doesn’t break down, but we, his readers, heartily wish it would. Further, the society depicted in *Brave New World* bears an alarming resemblance to the one in which we presently find ourselves.

Notes to Chapter Seven:
(2) Teaching tools were available for anyone wishing to internalize further the metaphor. The universe as Matter In Motion could be studied by those who played the recently invented game of billiards—a game that was all the rage at the end of the 17th century. Another powerful metaphor was The Clock, an indispensible part of every telescope; for, in the absence of a clock,
as the earth rotates on its axis, the telescopic image of any celestial object will drift rapidly, inexorably, out of the field of view. Therefore, a telescope must actually be mounted upon a clock. The universe as mechanical clockwork was such a powerful metaphor, that after the 17th century another teaching device, the orrery, became popular among the well-to-do. The orrery is a clockwork model of the solar system (not to scale); once wound up, the model planets proceed to revolve about the model sun. In addition to the visible message: the order of the planets and their orbits, there are the subliminal ones. (1) The universe is a machine, and (2) A scale model can be built; one which we can actually see.

(3) After 1660 King Louis XIV took the sun as his emblem, meaning that the French nation-state revolved around him. Here is an example of the concurrence of power and the boundless desire to use it.

(4) The coffee house was the headquarters for political unrest; Paris had 250 of them by the year 1690, and after that the number tripled in less than a century. The very notion of an “intellectual” (typically a writer) whose opinions are supposed to be worthy of public attention, is one that is quintessentially French. See The French, by Sanche de Gramont for a delightful, if painful analysis.

(5) For the philosophers it was a kind of rehearsal for the French Revolution. In Albert Camus’ The Rebel there is a description of the execution of Louis XVI, in which the king begs for his life on the grounds that the executioners, by killing him are killing God. In a sense, Louis was right. Just ask Nietzsche.


(7) This buzz-word was considered to be a very important idea at one time, especially in France, where one can still find hotels and cafés named after "le Progrès". Le Progrès was, together with Reason, the religion of the French Revolution. Voltaire’s tract has a special significance in terms of Daniel Quinn’s Ishmael. In the latter half of the 17th century the writer Bishop Bossuet had written that the surest cure for wicked behavior is a firm faith in Providence. The later disciples of Descartes argued that there can be no room for Providence in a mechanical universe. Voltaire argued that human progress is strictly material, and is solely the result of human effort. Thus we can see in Bossuet the last gasping breath of the ‘Leaver’ mentality, and recognize that Voltaire is speaking on behalf of the ‘Takers,’ as defined by Quinn, in his Novel: Ishmael.

(8) It was the steam engine, invented by Newcomen and improved by Watt, that inspired the invention of various mechanical devices for the manufacture of textiles. The inventors who gave England its industrial revolution were not the direct intellectual heirs of Isaac Newton whose center was London, but were actually the descendents of the Non-conformists, inspired mechanics, whose headquarters were in the Midlands: Birmingham—the location of Blake’s “dark Satanic Mills.” There is an entire library of good books on this subject. I recommend William Blake, Penguin, Harmondsworth, Middlesex , Pelican Books, 1944-1954, by the mathematician Jacob Bronowski. Also essential reading for an understanding of “how we got this way” are Witness Against The Beast, by E.P. Thompson, New Press, NY, 1993, and Rebels Against The Future, by Kirkpatrick Sale, Addison-Wesley, NY, 1995.

(9) A heat engine is one that takes in heat in the form of burning fuel, and converts some of it into useful work (like moving your car down the road) in the process. Another example is the steam engine. But there is always heat that is rejected. The exhaust manifold of an auto is much too hot to touch.

(10) It goes almost without saying that a technical discussion of thermodynamics is well beyond the scope of this book: See Fenn, John, Engines, Energy and Entropy, Freeman, SF, 1982, for a
beautifully written treatment at the level of elementary college physics.
(11) Consider the exhaust from a car; its temperature is far lower than that within the cylinders.
(12) In the case of Great Britain, for example, its traditional output has been in the form of textiles. The British government wanted to sell textiles (at a profit) to the American colonies in trade for hemp(!), which was used for sails and rope in their Navy.
(14) For a superb exposition of this, one of the most important experiments in history, see The Character Of Physical Law, 1965, MIT Press, Lecture No. 6, Probability and Uncertainty—The Quantum Mechanical View Of Nature, starring the great Richard Feynman.
(15) The equivalent rank in the United States is the Attorney General.
(16) It was Reynolds who had made the snobbish distinction between “fine arts” and mere “crafts”. William Blake, an engraver as well as a poet, loathed Reynolds with all his heart.
(17) For the first, see The Raft Of The Medusa, for the second see The Dead Matador, for the third see Le Dîjeuner Sur L’Herbe, in which linear perspective goes out the window. For a more complete discussion, see Art and Physics, by Leonard Shlain, Quill-William Morrow NY, 1991.
(18) Her novel, written in the early 19th century, was prophetic, and has much to teach us today. Feel free to disregard the movies.
(19) Moby Dick is one of the great classics of all time. It is a warning for all those of “single vision”: that the physicist who pursues Moby Particle, the general who pursues Moby Defense System, the CEO who pursues Moby Leveraged-Buyout—all of them are more than a bit mad. There is something about Americans: they don’t respect limits. In fact, it is possible to argue that, when writing Moby Dick, Melville was talking about America. I think that this is the truth!
(20) This tale is told in The Orphic Vision, Gwendolyn Bays, Univ. of Nebraska Press.
(21) Although it is the custom to name streets in Paris after politicians, generals, scientists and mathematicians (even obscure ones, if they were French), Not a single Parisian street is named after the latter three men. Nerval hanged himself from a lamp post on a Paris street. One would think that the authorities would have had the decency to name the street after him—or just the lamp post.
(22) Euclid’s 5th Postulate states that through a given point, one and only one line can be drawn parallel to a given line. It isn’t always the case.
(23) There is a very good, concise treatment of the effect of Mechanism upon the science of biology and upon Medicine, in Fritjof Capra’s The Turning Point , Bantam, NY, 1983.
(24) The knowledge that micro-organisms cause disease resulted in great advances in sanitation during the nineteenth century. Many epidemics were due to typhoid and cholera, both water-borne. Sadi Carnot died in Paris of both typhoid and cholera! Prince Albert, the consort of Queen Victoria, died of typhoid.
(25) On his deathbed Pasteur exclaimed that Bernard had been right, and that microbes were not that important.
(26) In a minority report, the botanist Jussieu mentioned that he had on occasion seen patients responding to the motion of the mesmerist’s pointed finger at a time when they could not possibly have seen the gesture. But he was overruled.
(27) The word le magnetisme, is still used in France to refer to trance induction.
(29) One of Charcot’s students was Sigmund Freud, who later renounced hypnotism in favor of
more Newtonian methods. But it was Freud who discovered the overpowering role of the Unconscious, during his stay in Paris. Today, on the wall of the building where Freud had been staying, (l'hôtel du Brésil) can be found a plaque (in French) bearing the words: “Here is the birthplace of psychoanalysis.”

(30) Notes sur Quelques Phénomènes de Somnambulisme, by Pierre Janet, Société de Psychologie Physiologique, Séances d’Octobre, Novembre, Décembre 1885.

(31) For a very readable account of the beginning of the War and the decades which preceded it, don’t miss The Proud Tower and The Guns Of August, Bantam, NY both by Barbara Tuchman. There is a great deal of valuable information for our times in her work. And you should also read her: The March of Folly.

(32) Positivism is an evolutionary theory of philosophy, which holds that magic, religion and metaphysics constitute earlier, imperfect, successive stages in the evolution of human thought, culminating in “positive” knowledge, based on observation of natural phenomena, empirically obtained.

(33) Holton, Gerald, Science And Anti-Science, Harvard University Press, 1993, page 2. Holton is the most eloquent of the Old Guard, the defenders of the Western Rationalistic Tradition. From his vantage point at Harvard he has been in a position to meet most of the key practitioners of that Tradition: "the last of the gun-toting sheriffs of the Old West". The translation is Holton’s own, from die Neue Freie Presse suppl. (Vienna) 12 June 1926.

(34) "the thing in itself."

(35) Einstein's early work, such as the Special Theory of Relativity, was heavily influenced by that of Mach. The General Theory, however, deals with the non-Euclidean geometry of space-time—a concept that does not harmonize readily with the simplistic ideas of John Locke, or of Mach either.

(36) Logical positivism, sometimes called logical empiricism, is a school of philosophy subscribing to the notion that all meaningful statements are either derivable from legitimate logical operations or confirmable by observation or experiment; and that metaphysical theories are meaningless. Fortunately for the rest of us, and unfortunately for the logical positivists, to be consistent, the above notion itself would have to be categorized as meaningless.

(37) Abstract painters followed suit; people like Wassily Kandinsky come to mind. And classical music styles too, such as those of Schönberg and Webern became more cerebral.

(38) Small wonder that the inhabitants derive so much spiritual satisfaction from vandalizing those places!
Perhaps we need to be much more radical in the explanatory hypotheses considered than we have allowed ourselves to be heretofore. Possibly the world of external facts is much more fertile and plastic than we have ventured to suppose; it may be that all these cosmologies and many more analyses and classifications are genuine ways of arranging what nature offers to our understanding, and that the main condition determining our selection between them is something in us rather than something in the external world.

E. A. Burtt,
The Metaphysical Foundations of Modern Science.

The Search For Explanations

In an earlier chapter we asked the question: "What is it that really constitutes a satisfactory explanation of any natural phenomenon?" After the Scientific Revolution one could supply the following answer to that question: "A satisfactory explanation is one which explains a complicated phenomenon in terms of a simpler one--one whose origin is better understood. When we say that the simpler phenomenon is "understood," we mean that it can be derived from one or more of the basic laws on nature--laws which are presumed to be intelligible to humans," or as Descartes would have it, "ones which present us with clear and distinct ideas."

After the Scientific Revolution four basic laws of nature were recognized: Newton's three Laws of Motion, and Newton's Law of Gravitation. All four of these laws involved the concept of force. In my youth, elementary physics texts used in secondary schools defined force as a "push or a pull," a very comforting bit of reductionism, since pushes and pulls are intuitive, relating, as they do, to our sensory-motor systems. But insistence upon this intuitive quality in physical explanations was to prove to be, as we shall see, frustrating. In this chapter we shall learn how the original intuitive simplicity of natural laws was really nothing more than an illusion. In fact, the more we learn of the language of nature, the more we learn that it is not our language.

Action At A Distance: Is It Magic?

Descartes, Gassendi and Hobbes, all of them leaders of the 17th century mechanists, had visualized the universe as an arena in which masses are continually colliding with each other, to produce all the physical phenomena as we know them. But Newton had been forced to permit an unwelcome interloper to infiltrate the billiard-ball world of the firm of Descartes, Gassendi and Hobbes. As we know, this interloper was none other than Universal Gravitation. For, apparently, material objects appeared to be able, in some strange, incomprehensible way, to act upon each other at a distance, even in the absence of any noticeable intervening medium. Newton had used this idea of universal gravitation to explain the motion of the moon about the earth, and was able thereby (at some point in his career at least), to predict from his theory the measured length of the month. Exactly why it is that bodies should attract each other with a force inversely proportional to the square of the intervening distance was more than a mystery; to the mind of the seventeenth century scholar it smacked of the occult, of action-at-a distance, of the kind of
lower-class belief-system that had been driven underground at the time of the Restoration of the English Monarchy.

Therefore Newton’s gravitational theory was at first greeted with disdainful suspicion by rationalist scientists on the European continent, men such as Huyghens and Bernoulli. Their own goal, as materialists, had been to drive enchantment completely out of the world. It had been their practice to try to construct the laws of the world around such concepts as “matter” and “motion.” Even Newton had expressed an unhappiness with gravitation, in a letter to Richard Bentley, an Anglican minister. But what are the available alternatives? There are two: either we can assume that objects can act upon each other through totally empty space, or we can assume that space isn't empty at all--that it is filled with an invisible entity that can convey forces from one point to another, so that it is difficult to tell where one body leaves off and the other begins. But in the end it was pointless to argue with the moon, which obstinately followed Newton’s schedule. So gravitation was here to stay, mystery or no, no matter how one chose to talk about it.

**Hair-raising Phenomena, Known From Of Old.**

But gravitation was not the only known form of action at a distance. In ancient Greece it had been observed that a piece of amber when rubbed, had the power to attract small pieces of lint, and to make the hairs on one's body stand on end. Also, more than two thousand years ago, Chinese sailors were navigating, using the magnetic properties of lodestone. Already, during Newton's lifetime, amateur researchers were actively puzzling over these mysteries. But electrostatic phenomena were much more complicated, much more mysterious than gravitational ones. For one thing, the power to attract or repel objects did not seem to reside in the objects themselves, but seemed instead to be the property of a kind of “fluid” that was produced by rubbing the objects together. Sometimes the “fluid” was free to move about from one object to another, carrying with it the ability to produce attractions and repulsions, but at other times not. Why were the forces attractive at one time, and repulsive at another? Also, included among electrostatic phenomena was the production of sparks, like so many miniature lightning bolts. Clearly, the amateurs had their work cut out for them.

Six years after the death of Newton, a blind Frenchman, Charles François du Fay, was able to demonstrate that there were actually two opposing types of “electrical fluid”; and that these produced either attraction (between objects containing opposite fluids), or repulsion (between objects charged with the same fluid). Over the course of the 18th century these electrical effects became the subject of investigation on the part of a growing class of “semi-professional” scientists; in this genre, some of the best thought-out research was carried out by Benjamin Franklin, even as early as 1750. Finally, in a paper published in 1791, Charles Augustin Coulomb was able, by a most ingenious experiment, to show that the force acting between two electrified bodies, whether attractive or repulsive, is similar to that of gravitation in that it, too, is inversely proportional to the square of the intervening distance. By way of analogy with gravitation, at that time it seemed reasonable to talk of electrical charges and forces as if they were exclusively properties of matter; and the fact that gravitation itself had once been recognized as inexplicable and grossly occult had been conveniently forgotten.

After Coulomb's discovery, in a brief span of time, more important discoveries were made. In Italy Alessandro Volta discovered how to make a battery using two dissimilar metals and a salt solution. Now it became possible to create, at will, electric currents in wires. Shortly after that, in Copenhagen, a high school teacher named H. C. Oersted held a magnetic compass in the vicinity of a current-carrying wire; and to his astonishment, the compass needle was deflected. Here was the first evidence that an actual connection exists between electricity and magnetism. We have a classic example of two phenomena, originally placed in separate categories, being shown to cohabit within a larger, more general category. A short time later, this discovery was given a brilliant theoretical explanation in France by the mathematician André M. Ampère. However, the next, and most exciting experimental discoveries were
Michael Faraday, Outstanding In His Field

The life of Michael Faraday had a certain fairy-tale quality about it--he was almost too good to be true. Born into poverty, and apprenticed as a child to a bookbinder, he started attending evening lectures on science, given by the famous chemist, Sir Humphrey Davy. Young Faraday found himself captivated; and, by a combination of persistence, genius and luck, in a short time became a scientist in his own right, working in The Royal Institution, a laboratory funded by the Crown. Although he was completely self-taught, and knew no mathematics beyond arithmetic, he was a natural genius, and quickly became the greatest experimentalist of his time.

Faraday's imagination and lack of formal education caused him to think about the universe in a way that was totally original. Older scientists, trained in the tradition of Descartes and Newton, had thought about the world in terms of atoms--masses, (theoretical constructs, these!), as having an existence separate from their properties--properties such as electric charge, for instance. But Faraday was interested solely in experimental results, and the ones he could measure were forces. These forces could be measured everywhere in the regions surrounding the charged bodies, so Faraday started connecting his points of measurement by drawing lines between them. For him, the lines he drew were the real entities, and the bodies were merely the intersection points of the lines--which he first called "lines of force".

One night in 1846 Faraday's shy, nervous colleague Wheatstone had been scheduled to give a popular lecture before a large audience. But at the last minute, he was seized by a fit of stage fright; and terrified, the man fled, leaving Faraday to carry on alone. Lecturing extemporaneously, Faraday proceeded to describe to his audience his concept of The Field. His reasoning was as follows. We know that the sun attracts the earth. But suppose, for a moment, that the earth had been initially absent. Upon being installed in its customary place, would the earth start to feel an influence which had already existed before that time? Faraday's answer was Yes, there was already an influence, acting at that point, even when it was unoccupied. There exist, he said, gravitational "field lines," due to the sun, ones that are already present. These turn into lines of force, once the earth is placed there for an interaction to occur. The presence of the sun has already changed the state of affairs in its surrounding space. Of gigantic significance is this, the concept of the Field--as we shall see later. In his lecture, Faraday went on to say that light is not a vibration in some kind of rare mechanical medium (called the æther), but is rather rather a vibration of the field lines themselves. His impromptu audience had unknowingly been present at a moment of great historic importance. Although the facts bore him out, many of the members of the audience undoubtedly felt that Faraday had finally gone too far. But had he really? Read on; let us see....

Over the years, this brain child of Faraday's has had an interesting career.

• First, it represented another step away from the Cartesian idea: that of describing all phenomena in terms of matter and motion, for Faraday's fields do not require the presence of any colliding particles--but merely concentrations of field lines.

• Second, it proved to be a fateful move in the direction of increasing abstraction, because fields are far from being intuitive entities, as forces are. As we shall see, the best way to express the universe seems to be through abstract mathematical relations; but the problem is that then we know only the relations, not the meaning of the nouns. This means in fact, that it is impossible to "explain" the electromagnetic field in terms of anything other than the equations themselves. And with the passage of time, physicists would have to learn how to accept more and more abstraction in their attempts to explain phenomena. The more we try to explain the universe to ourselves, the less intuitive the explanation becomes.

And Now Maxwell, And The Grand Abstraction
In 1864 a Scotsman named James Clerk-Maxwell looked at Faraday's field lines and recognized that they could be described by a mathematical formalism already in use in the science of hydrodynamics. Thus inspired, he wrote down a set of equations, known today as Maxwell's equations, describing all of the known behavior of electric and magnetic fields. An interesting by-product of this exercise was that the electric and magnetic fields, acting together, can behave as waves--including those waves that we know as light. They can even propagate indefinitely, in the absence of any intervening matter. And you can see, on any starry night, that this is indeed so.

Maxwell’s mathematical manipulations had been indeed brilliant, but his mechanistic mind boggled at this nagging little question: "All right—so the fields are waving—but waving in what? Is there some infinitely subtle substance—call it the æther, that is filled with invisible vortices, sources and sinks, like water in a stream, in which the field lines are imbedded?" No one could answer that question, but Maxwell knew that his mathematical description was an apt one, for when he used it to calculate the speed of light, his answer agreed nicely with the observations. However, by now the fields had become so divorced from anything resembling matter, that “matter and motion” had become no longer sufficient to explain the world. Further, the concept of action-at-a-distance was no longer adequate to describe what was being observed. Only Faraday's electric and magnetic fields were necessary to explain the facts. But Maxwell balked at all this, and reintroduced the æther, in order to be able to give a mechanical explanation of electricity and magnetism. However, Maxwell's æther, as we shall soon see, would not be able to compete for long on the only playing field that really counts: The Laboratory, where experience would trump theory.

Maxwell's great triumph in 1864 was his calculation of the speed of light from his equations involving only electric and magnetic fields. The experimental results obtained by others over the previous 200 years already agreed nicely with his mathematics. But there still remained a problem. For a vibration to travel at the speed of light through a medium, that medium must have an enormous tensile strength--greater than that of steel. Also, to be transparent to light, the æther would also have to be like an incredibly rarified form of “jello," since it also must have the wispy properties of empty space. Therefore, one is left with a paradox: how can empty space have non-zero tensile strength?

One hundred thirty-eight years after Maxwell's discovery, we feel that we are in a better position to understand his equations. So let us indulge in a game of Question and Answer.

Q: What do these equations signify?
A: You mean: "How are they to be interpreted?
Q: Yes. What do these electric and magnetic fields mean?
A: There is no evident interpretation beyond the equations themselves. They constitute a recipe for calculating electric and magnetic fields. When you look at the equations, the only variables present are those fields. Why should you imagine that you are entitled to more information than is there on the page? The only connection the fields have with us, is that the fields can be used to compute actual forces; but that doesn't tell us what the fields "are," for that would mean that we can explain the fields in terms of something simpler and more intuitive. Well, we can't--apparently it is impossible in principle!

Kelvin's Clouds

In the year 1900 Lord Kelvin, in his role as Elder Statesman of British Science, delivered an address on the subject of the future of science. Although he allowed modestly that there was not really much more for science to do, and that any further discoveries would probably be merely incremental in nature, (possibly some corrections beyond the third or fourth decimal place); he could still discern "two tiny clouds" hovering on science's horizon. One of these clouds was the null-result of the Michelson-Morley experiment.

And The First Cloud Brings Forth Rain
As early as 1881 the American physicist A. A. Michelson had gone hunting for the æther by means of an ingenious experiment, involving the splitting of a light beam into two parts. Here is the crucial reasoning: if there is really an æther, then the earth must be traveling through it. If we send one part of the light beam, (a wave), along the earth's direction of motion until it strikes a mirror and returns, while simultaneously sending the other part of the light wave at right angles to the direction of the earth's motion to a destination at a second mirror, then when the two waves are reunited, the time of travel along the former path will have been greater than the time of travel along the latter path. Thus the two waves will be slightly out of step with each other, and this difference can be easily measured. Michelson tried the measurement, but he returned empty-handed. The travel times in the two directions were always equal. Moreover, his cunning experiment, performed repeatedly by others over the following ninety years, always produced the same null result. At one time the mathematician Jacob Bronowski described this null result as “a murmur at the heart of physics”. From Michelson's result it can be concluded that light waves do not require a “material medium” for their propagation, for the æther is undetectable, and can be therefore safely held to be non-existent. It can even be said that it is the fields themselves that do the waving, for Maxwell was able to show that it is in the fields that the energy resides, and nowhere else. But what, then, is a field? Read on!

Refinements of the Michelson-Morley experiment have been made repeatedly over the ninety years that have elapsed since its first outing; the latest of these attempts showing that the motion of the earth through the æther, if it exists at all, must be less than five centimeters per second! Since the earth’s orbital motion around the sun is close to thirty kilometers per second, this means that the measured result is only 1/600,000 as large as the one predicted from assuming the existence of the æther. Moreover the discrepancy can be doubled by a simple rotation the interferometer through 180 degrees. This is why we consider the null result of the Michelson-Morley experiment to be so decisive. There is just no evidence for the existence of a material æther.

As we have already seen, in the nineteenth century, for a mechanical model to be respectable, there just had to be a medium in which electromagnetic waves could travel, and the æther was the obvious candidate. After all, Water waves travel in water, and sound waves travel in air, (usually). In order for you to appreciate the tyranny of this kind of mechanistic thinking, let us listen to Lord Kelvin, the Grand Old Man, who was speaking for many of his colleagues when he confessed in the year 1884:

I never satisfy myself until I can make a mechanical model of a thing. If I can make a mechanical model I can understand it. As long as I cannot make a mechanical model all the way through I cannot understand; and that is why I cannot get the electromagnetic theory....

But It Was The Second Cloud That Brought A Real Downpour.

It was the lack of evidence for the æther that constituted the first cloud. But the second cloud was even more mysterious; for it was the total inability of science to explain as tantalizingly simple a thing as the color of a heated object. But first we need to have some background information in order that we can understand the nature of the problem; for its solution, given by Max Planck in the year 1900, has changed our view of the world in ways that no one could ever have guessed.

When light falls upon an ordinary object, some of its energy is reflected, while the rest is absorbed. But what is not so obvious is that the light that is absorbed must also be re-radiated. For if this were not the case, the object would, in a short period of time, become unbearably hot. In a closed system all the objects have to be at the same temperature. Therefore, as they absorb, so must they radiate. For example, a black object (called a blackbody) is one that absorbs all frequencies of light that fall upon it. But in order to conserve energy such an object must also radiate at all possible frequencies—that is, in all
possible colors. It is easy for us to miss this fact, for at room temperature we cannot see any of the light that is radiated by a “blackbody.” At that temperature we only see the reflected light; at room temperature the blackbody radiates in the infrared portion of the spectrum, in colors invisible to the human eye. However, you can detect the radiation from the back of your hand, merely by placing it close to the skin of your cheek just below the eye; the skin of your hand is radiating, and the skin of your cheek can “see” it. What is surprising, is that the sun has almost all of the characteristics of a blackbody—one having a surface temperature of 5500 degrees on the Kelvin scale, so that its radiation appears yellow to the eye. So, now that we have a better understanding of what is involved, we can actually use the sun’s yellow color to measure its temperature.

Although blackbodies radiate all colors, the predominant color of this radiation will gradually shift from red to yellow to violet as the temperature of the body increases. But at the end of the nineteenth century this was still all very mysterious. No one knew why heated objects behave that way. Furthermore, the solving of that mystery has led us to yet another, far deeper one—one that was to change forever our way of thinking about ourselves and our relation with the world.

For us to be able to understand something about the color of a glowing object, it is a good idea to start out by thinking of a vibrating string. Think of a string having a length \( L \). Then, (see Appendix A), the longest wave that can “stand” upon that string is one whose wavelength \( \lambda \), is equal to \( 2L \). From Appendix A you can see that the frequency of this wave, the longest wave on the string, is \( f_1 = c/2L \), where \( c \) is the speed of light. By studying the diagrams, you can see that it is always possible to have waves that are shorter than \( 2L \), but never ones that are longer. Longer waves are forbidden by the limited length of the string. But wavelengths are inversely proportional to frequencies. From this it follows that, if we talk instead in terms of the frequency of the waves, it is always possible to have frequencies that are higher than \( f_1 = c/2L \), but never ones that are lower.

Next, we need to understand that a blackbody really acts somewhat like a string—a vibrating three-dimensional string, really—a wiggling jello. Thus, if our string absorbs a quantity of energy, it should radiate that energy back at us in a mixture distributed over all frequencies, (all “colors”). But infinitely more high frequencies are possible than low ones, since there are infinitely more short waves on the string than long ones. Reasoning in this manner, we are led to the impossible conclusion that the string should radiate preferentially in colors corresponding to higher and higher frequencies: not red but yellow, not yellow but blue, not blue but violet, not violet but ultra-violet, and so indefinitely, no matter what the temperature of the body will be! This purely hypothetical situation was referred to as the “ultraviolet catastrophe”, since speaking classically, this should be the final condition of the world.

Finally there comes a cheering realization. This is not what actually happens; in the real world there is really no ultraviolet catastrophe. What we actually experience is that the color of a heated body becomes first noticeable to us as a dull red; then, only as its temperature rises, the color shifts smoothly through orange and yellow, toward the violet end of the spectrum. This was the embarrassing conundrum that baffled the best minds of the last part of the nineteenth century: why does the color of an object depend smoothly, and only, upon its temperature?

The answer to this question was really a simple one, but scientists of the time had been carefully schooled to avoid it. To get the temperature of the body to rise, you have to heat it; thereby adding energy. That’s how you get the color shift. But then there must be some secret connection between the energy and the color—and therefore also a connection between energy and frequency! This was the crucial step, announced on 14 December 1900 by Max Planck, (in opposition to every scholarly instinct he had). He said something like: “let’s assume:

- that atoms of the blackbody are little oscillators, (like masses hanging from springs), that they absorb energy not smoothly, but in discrete packages; and further,
- that the frequency at which they radiate (which of course determines the color of the blackbody) is
proportional to the amount of energy which they have absorbed, (and which they therefore re-radiate)”. This discovery is expressed by the now famous equation:

\[ E = hf, \]

where \( E \) is the energy radiated or absorbed, \( f \) denotes the frequency associated with the color of the light, and \( h \) is a number called Planck’s Constant, in honor of its discoverer. Planck’s Constant is really a very small number—a fact which accounts for the fact that the trajectories of macroscopic objects appear to be smooth, and not jerky. In defense of his bold hypothesis, Planck then proceeded to show that the distribution of energy among frequencies given by his theory was identical with that which was observed in the laboratory. Heretical as his ideas were, (and they were even hateful to him), he wisely considered it foolhardy to argue with the facts. This is why, on the fourteenth of December, we should celebrate the birthday of the quantum theory—after which our view of reality had to change—in ways that are impossible to guess, even now.

When Are There Atoms?

There is an ancient and well-known hypothesis: namely, that what we call “matter” is composed of tiny, gritty, irreducible particles, called “atoms”. This, the Atomic Hypothesis, was first stated during the fifth century BC by the Greek philosopher Democritus, who summed up his picture of the universe by saying:

By convention sour, by convention sweet, by convention colored, in reality only atoms and the void.

In his long poem: On The Nature Of Things, Lucretius, a Roman philosopher, gave a summation of Democritus' theory, expressing it in a fashion that turned out to be more compatible with 17th century materialism. After the time of Lucretius the atomic hypothesis lay dormant for a long while. Even after Lucretius' poem was rediscovered in 1419, no great interest was shown in atoms until Galileo's time, 200 years later. But from then on it became a kind of working assumption, even a kind of mantra, or a mania, especially of mechanistic philosophers such as Gassendi, Hobbes and eventually, Newton.

In the early part of the nineteenth century the chemist John Dalton discovered the Law Of Multiple Proportions: the idea that elements combined with each other in simple ratios. Dalton understood that some kind of atomism was necessary in order to explain the orderly way in which chemical compounds interact; but still a nagging question remained: how do these atoms hook together? If the atoms have "hooks," then they should have some kind of internal structure! But if they had structure, they wouldn’t be true atoms, would they? After all, atoms are supposed to be indivisible! But even as late as 1875, James Clerk Maxwell, one of history's greatest scientists, felt that he could safely describe atoms only in terms of the following mythology: as “foundation stones of the material universe...unbroken and unworn”: an expression of radical atomism. And to make matters even more interesting, the distinguished German scientist Hermann Helmholtz pointed out that if we accept the idea of atoms of matter, we are driven to conclude also that there must also be atoms of electricity, since electric charge seems to inhere in matter.

J. J. Thomson And His Corpuscles

This was how the matter stood until certain refinements were made in the construction of the cathode ray tube, a development which led to the discovery that the atom actually can be spoken of as being made of “parts”— that the word “atom” does not really mean: atom, in the etymological sense of the word. In the year 1897 at Cambridge University’s prestigious Cavendish Laboratory, its Director, J. J. Thomson, while investigating the eerie glow emanating from the region between two electrodes placed in an evacuated tube, was able to measure the ratio of charge to mass of the particles emanating from one of the electrodes, (the one called the cathode). At the time, he referred to these particles as
“corpuscles”; but today we call them “electrons”. This experimental feat, followed by his successful measurement of the electron's charge alone, was to bring him fame, and ultimately the Nobel Prize. However there is much more to this story; and in order to bring its parts together, we first need to shift our scene of events to the sleepy town of Bern, Switzerland, on the banks of the river Aare.

A Swiss Patent Clerk Finds A New Application For The Quantum.

As early as 1887 Heinrich Hertz, a young German, who had been experimenting with the sending and receiving of electromagnetic waves by means of tuned circuits and spark gaps, observed that when light was allowed to fall upon the gap, the current-carrying spark occurred more readily than if the gap had been left in darkness. This was indeed a puzzle: just what was it about light that caused electric current to flow across that gap? This question was investigated without much success until the year 1900, when it was shown that the observed current emitted from the cathode could not be made up of atom-sized pieces of the material of the apparatus. But what, then, could the current consist of? Shortly afterwards, the mysterious current was shown to consist of none other than Thomson’s negatively charged “corpuscles”. So by now, Thomson's corpuscles seemed to be appearing everywhere, but an understanding of the phenomenon still eluded everybody. Finally, in the year 1905 a solution to this problem appeared. The Photoelectric effect, as it is now called, was explained, for the moment, by a hitherto unknown Swiss patent clerk named Albert Einstein.

Einstein’s reasoning was extraordinarily simple. He proposed that some the corpuscles lay inside a piece of metal like peas in a pot of pea soup. When the light fell upon the metal, part of its energy was used to eject the electrons from within the metal, just as one could, by bombardment, get peas to splash out of the soup. The rest of the energy was kinetic: the energy of motion of the electrons. And what was the energy of the incident light? Einstein hypothesized that it was that same energy predicted five years earlier by Max Planck:

\[ E = hf. \]

This result represented a new (and somewhat unwelcome) turn of the screw for Professor Planck. Henceforth, it would be much more difficult to treat his constant \( h \) as he wished: a mere calculational “gimmick”, because if that mysterious quantity, \( h \) persisted in turning up in this, a completely different context, it might just be some kind a universal constant--an important intrinsic property of the universe!

By now it was beginning to look as if the cat were irretrievably out of bag; and that the quantum was here to stay. Moreover, each new revelation seemed to draw researchers ever farther from the familiar world of their forebears, and farther into that Labyrinth, in which is concealed the unknowable heart of Reality. (We shall return to this adventure shortly.)

The Heart Of The Matter: The Nucleus

Thomson's discovery of the ultra-light "corpuscle", later named The Electron, offered only a partial explanation to the question of how atoms are held together to form molecules. For Thomson's electron carries a negative electric charge. And since the atom itself is electrically neutral, it follows that there must be positive charges lurking down there in the nethermost bowels of the atom, placed there so that nature's books might be balanced. Then, as hypothesis had it, the positive charge on one atom would be attracted to the negative charge on a neighboring atom, thus creating a molecular bond. This idea seemed promising, but scientists still demanded some kind of a picture: What did an atom look like?

Thanks to the irrepressible J. J. Thomson, the scientific community did not have to wait very long for a model, but it was a fairly bizarre one. Thomson considered the positive charge of an atom to be uniformly smeared throughout its entire volume, like a positively charged jello, or as the English would have it, a pudding. Thomson was able to show that the negative electrons would normally vibrate back and forth about their static positions in the atom, in the manner of charged raisins jiggling back and forth
in a kind of elastic plum pudding. However, objections were soon raised to this idea, for it had long been known that electric charges cannot be maintained in static equilibrium under purely electrical forces. This latter condition was a simple consequence of Maxwell's equations, and therefore difficult to overcome, for Maxwell had become Holy Writ. What justification did Thomson have for violating this commandment? Always pragmatic, he pointed out that the proof of the pudding was in the eating, and then proceeded to show that many optical and electrical features of matter could be calculated by means of his strange model. So at first Thomson appeared to have the facts on his side, but appearances can be very deceptive. There is always something suspicious about a theory that isn’t quite crazy enough, and it is not only in Greek plays that Hubris is punished by Nemesis. In the following chapter we shall see how all this played out.

Notes to Chapter Eight:
(1) Billiards came into fashion during the last half of the 17th century. The collisions of billiard balls constituted an important metaphor for the Mechanists—a cultural teaching tool; it was their model of the way in which things happen in the world.
(2) Newton wrote: “That gravity should be innate, inherent and essential to matter, so that one body may act upon another at a distance through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it...”
(3) Amber is fossilized pitch, which the Greeks called elektron.
(4) Catching The Light, by Arthur Zajonc, Bantam, NY, 1993, for a more complete discussion of this topic.
(5) Initially, electric fields had been regarded as regions where the “state of affairs” had been changed by the introduction of charged bodies. The force experienced by an electrically charged body (a “test charge”) is considered to be a measure of the strength of the field in which it has been placed. Once it had become recognized, as in the case of electromagnetic waves, that electromagnetic fields can exist even in the absence of charged bodies, it was recognized that the original definition of the field was still a good one. The existence of a change in the “state of affairs” is signaled by the force that is exerted upon the “test charge”, that we place in the “field”. But what is a field? A figure of speech, no?
(6) Faraday recognized that we know objects only by their attributes, and that it is not necessary to assume that atoms have any independent, material existence apart from the forces that they generate. This idea will return to haunt us.
(7) If Maxwell had been successful it would have been a final victory for “contact” forces, like those of Descartes over “action-at-a-distance” like that proposed by Newton. Maxwell’s æther was conceived of as having a large number of mechanical attributes, ones that would have turned the Universe into a giant, deterministic machine.
(8) This experiment was performed by Alain Brillet and Jan Hall in 1977.
(9) To be sure, dear reader, a blackbody acts more like a kind of three-dimensional string. But the one-dimensional explanation preserves the essentials; so we shall, in the interests of simplicity, let it stand.
(10) What Planck had hoped to show was that his quantum assumption was a kind of mathematical gimmick, one which could be made to disappear in the final equation describing the distribution of energy radiated by a body at a given temperature. In the end his hopes were to be dashed; the cat was out of the bag.
(11) The word “atom” comes from the Greek word “a-tomos”, meaning “non-divisible”. The atomic hypothesis began to have respectability in the seventeenth century, and occurs in the later work of Isaac Newton.
(12) The cathode ray tube is a simpler version of the picture tube on a television set. The cathode is the negative terminal. A high voltage drop between the terminals produces a gratifyingly large stream of charges.
(13) What he had thereby created was the first radio transmitter and receiver; this is exactly how a radio works. The spark, of course is created by the passage of an electric current through the air.
(14) Einstein’s paper on the photoelectric effect appeared during the same year as the first of his papers
on the Theory Of Relativity. But it was his theory of the photoelectric effect that won him the Nobel Prize in 1921. The Nobel committee thought that they understood the former theory, but they were sure that they didn’t understand the latter one.

(15) It actually appears as if Planck was of a divided mind on the subject of his brainchild, the quantum. Once, while on a walk with his son, he confided to the lad that his discovery was equal in magnitude with those of Copernicus and Newton.

(16) Hence the colorful name given to Thomson’s exotic creation: The Plum Pudding Model.

(17) This is a result of an equation that must be obeyed by all electrical charges. “In the trade” it is referred to as Earnshaw’s Theorem. Electric charges, under displacement, would find a way to either stick together or fly apart. If you want to visualize this, think of a ball lying on a mountain pass. There is always a path downhill, so that the ball can roll far, far away. And it is always like this for electric charges. QED.
CHAPTER NINE
ENTER NIELS BOHR

“When the clock strikes 13, not only do you doubt it, but it also casts doubt on the previous 12 rings.”
Mark Twain

"...a small research of his own."

By the year 1896 Thomson’s Nemesis had already arrived at Cambridge, in the person of a young graduate student from New Zealand named Ernest Rutherford. After completing his doctoral studies with Thomson, Rutherford moved first to McGill University in Montreal, and then back to England, into a new laboratory at The University Of Manchester. Rutherford's personality contrasted radically with that of Thomson. The latter was introverted and egotistical, whereas the former was a generous, warm, gregarious man, even given to bursts of song at moments when he had made one of his many important discoveries. His personal magnetism drew talented people to his laboratory, and made him a pioneer in the employment of research teams. Some of his students even went on to win the Nobel Prize on their own.

It was on a fateful day in the year 1909 that his assistant Hans Geiger appeared in Rutherford’s office, asking if it would be proper for “young Marsden” to be permitted to start “a small research of his own”. This “small research” consisted of bombarding a piece of thin gold foil with alpha particles\(^1\), in order to see if any of them would perchance be deflected through a large angle. The alpha particles, in passing through the foil, were expected to suffer little if any deflection, and to impinge unmolested upon a screen. The latter was coated with zinc sulfide, a substance which luminesces briefly when impacted by particles. The location of the minute flash of light on the screen would then be the measure of the size of the deflection of the alpha particle, which carries a positive charge. Later, in his reminiscences of the event, Rutherford confessed that he had not really expected any unusual result from the experiment: “It was quite the most incredible event that has ever happened to me in my life....” But in retrospect the whole thing was uncanny. What Marsden saw (after his eyes had become sufficiently dark-adapted) was that a few of the alpha particles were indeed being deflected through large angles. But to produce a large angle of deflection requires the application of a correspondingly large force. The latter can only be the result of a positive charge being tightly concentrated in a massive object, localized in a very small region of space. Patiently, Rutherford sketched out the consequences of the presence of a heavy nucleus lying at the heart of the atom, and by 1911 he published his result, showing that the observed distribution of alpha particles on the screen was in perfect agreement with the idea that, at the heart of an atom, lies a tiny, massive nucleus, around which orbit the negatively-charged electrons. Thus, on that day in May 1909 the “nuclear atom” was born, and “Young Marsden” got his unexpected result.

Louis Pasteur once remarked: “Fortune favors the prepared mind”. It was certainly true on that occasion.
Rutherford’s model had a disarming familiarity about it; it was, after all, a miniature model of the solar system: one in which orbiting planets were replaced by orbiting electrons, and the gravitational forces by electrical ones. Thus Rutherford was using the solar system as a metaphor for the atom. But, just as in the case of Thomson’s model, there was a serious, possibly even a fatal, difficulty. This lay in the fact that orbiting electrons are continually deflected by the attractive force field of the nucleus. This deflection implies that the particles, in following their curved paths, are constantly being accelerated. From electromagnetic theory it can be shown that an accelerated charge is constantly losing energy; a fact which leads to the conclusion that the orbiting electrons should have promptly spiraled inward, crashing into their parent nucleus long before any of us were born; and consequently bringing the universe to a premature end. Thus both Thomson’s and Rutherford’s models were actually impossible under the accepted laws of physics—as they were understood at that time. And therefore, something was going to have to give way.

**Bohr Goes To Work For Rutherford.**

At this point, almost as if on cue, there walked onstage one of the most remarkable thinkers of all time: a young Dane named Niels Bohr. In the fall of the year 1911 he had come to Cambridge, then as now a Mecca for scholars, for the purpose of doing post-doctoral work under the great J. J. Thomson. But weeks had passed, and Thomson had still not gotten around to reading Bohr’s dissertation. Perhaps there was a small matter: the fact that at the first meeting between them, Bohr had tactlessly pointed out the existence of certain errors he had found in Thomson’s work. In any case, it is known that Thomson was something of a loner, a man of reserve, whereas the very soul of Bohr’s style was conversation. He was given to conducting arguments that would last until the small hours of the morning, only to be resumed later in the following day. In short, Bohr learned by conversing with people; and, unable to receive stimulation, he felt himself withering on the vine at Cambridge. But shortly after Christmas, Rutherford came to Cambridge as the invited speaker at the annual Cavendish Dinner. His topic, of course, was his recent discovery of the nuclear atom. And also of course, Bohr was present in the great dining hall that evening to hear Rutherford speak. Totally captivated, he lost little time moving his base of operations to Rutherford's laboratory at Manchester, and so altered the course of human history.

**The Key Assumptions**

To start with, it was Bohr who showed that Rutherford's model was closer to the truth than was Thomson's. Exactly how this came about is one of the great tales in the history of science. During the years 1912-13, whether in Manchester or at home in Copenhagen, Bohr remained continually in close intellectual contact with Rutherford and his co-workers, sketching in the rough outlines of the physics of the atom, intuitively anticipating discoveries that would not be made until years afterward. But if we want to come to an understanding of the behavior of complex nuclei as well as of molecules, it’s necessary to begin by addressing the problem of why the “orbiting” electrons continue to retain their energy, even while being accelerated: this is the problem of the stability of the Universe--a consummation devoutly to be wished. Bohr’s extraordinary empirical approach to the problem can be summarized in the following way:
- The “orbiting” electron, obedient to the laws of classical physics, radiates away its energy—except when it doesn’t, (a radical idea, that one). An electron that does not radiate energy is said to be in a “stationary state”.
- When the “orbiting” electron moves from one stationary state to another, that’s when the radiation of energy happens; and that energy is radiated in quanta—in "lumps"—following Planck’s Law!

"As soon as I saw Balmer's formula, it was all clear to me."

But how does the quantum enter the picture? After all, there has to be some kind of rationale for bringing it onstage. It was at this point in his career Bohr had the good fortune to encounter his old friend, H. M. Hansen. Hansen, a fellow Dane who had become an expert in the science of spectroscopy, had one very important piece of information to share with him: it was about spectra. When the light of the sun is passed through a prism we get the familiar solar spectrum: a smear of colored light, its visible portion spanning the range of colors from red to violet. But if instead we place a blob of table salt upon the end of a long wire and heat it in a gas flame, the flame suddenly takes on a deep yellow-orange hue. When its light is passed through a prism there is little contribution to the spectrum save from the color yellow, a result of the presence in table salt of the element sodium. By now the significance of this phenomenon was clear: by Planck’s formula, only one color means: only one energy. What we expect to see when we study a spectrum of an element is a display of various energies. But if we wish to understand the spectra of elements, it is wise to start first with the simplest example. And of all the elements in the Universe the one having the simplest, most fascinating spectrum is hydrogen. See figure 9-1 (below).

![Figure 9-1](image)

When viewed through a spectroscope, hydrogen displays a set of sharply delineated, thin bands of colors, principally: red, blue-green and violet. When the frequencies associated with these colors are measured, they follow a certain cryptic but suggestively orderly sequence: a kind of Rosetta Stone for scientists--a tantalizing and cryptic message that cries aloud for somebody to decipher it. And it was from Hansen in 1913 that Bohr learned of the first key to that cipher.

It had come in 1885 from the work of a Swiss high school teacher named Johann Balmer, whose
discovery can be described in the following fashion. The frequencies associated with the bands possessed certain numerical regularities: They are proportional to the following numbers: $1/2^2-1/3^2$, $1/2^2-1/4^2$, $1/2^2-1/5^2$, and so on. Significantly, Bohr had already numbered the stationary states in his model of hydrogen: 1, 2, 3, etc. Later Bohr was to say: "As soon as I saw Balmer’s formula, it was all clear to me.” Bohr instantly saw that the atom’s emission of light could be seen as the result of the energy change between any two stable orbits, as the electron jumped from one to another.

To understand this, one needs to observe that Planck’s quantum constant has the characteristics of a certain physical property called angular momentum; hence, said Bohr, what harm could there be in starting out by assuming that it is the angular momentum of the orbital electron that is quantized? Next, Bohr wrote out the expression for the energy of the orbital electron in the electric field of the hydrogen nucleus. Finally, he wrote the expression for the centripetal force on the electron. Extraneous variables could be eliminated, and there it was: a mathematical expression for the frequencies of the hydrogen spectrum, (see Appendix B).

Out in front of this expression stood a complicated constant, involving the electron mass, its charge, Planck’s constant and the speed of light. When Bohr had calculated its value: it came to:

$$R = 109,500 \text{ cm}^{-1}.$$ 

In the years after Balmer’s original discovery, the Swedish spectroscopist J. R. Rydberg had built on the work of the former,

![Figure 9-2](image)

Figure 9-2
Bohr radii and allowed energies of hydrogen. The first few lines of several of the spectral series of hydrogen are shown at the left.

and had developed an empirical equation to account for the frequencies of the lines in the
hydrogen spectrum. Bohr’s value, obtained from his daring quantum hypothesis, differed from the one measured by Rydberg by less than 2 parts in a thousand! This meant that henceforth any description of the behavior of the atom was going to have to be a quantum description. And however outrageous his assumptions had been, Bohr had placed his key in the lock of nature, and the key had turned!

A useful guide to Bohr's model is seen in the diagram of fig. 9-2. On the left we can see the quantum jumps that produce the spectral lines visible in figure 9-1. On the right side of the diagram are represented the corresponding orbits--the ones between which the jumps occur. The orbits and their energies are fixed by the quantization of the angular momentum. On the left side are the corresponding energies.

**Discontents And Inadequacies**

It must be admitted that Bohr was conscious of the inadequacies of his model. To talk about it, one was required to visualize a kind of circular amphitheater, with electrons rolling about the center, as if along the benches. The electrons could only receive energy by being struck like billiard balls, by other electrons or by electromagnetic waves. The metaphor of electrons visualized as tiny balls of charged matter, engaged in jumping from one classical orbit to another, seemed entirely out of character with the outlandish, madcap idea of the quantum. Frankly, the whole theory had a disturbing jerry-built quality to it; leaving one feeling unsatisfied—especially if one had been trained in the methods of classical physics, with its emphasis upon mechanical models. Moreover, the electron was supposed to be an actual particle of matter; and the approved model for matter in motion, the classical paradigm, was the smooth, continuous trajectory of a projectile, as visualized earlier by Galileo. Bohr knew that sooner or later he would be called to account for these awkward gaps in his theory. Sure enough, his first taste of what was to come occurred at his first meeting with Einstein in 1920. At that time the latter let it be known that he objected to any theory that “left to chance the time and direction of the elementary processes.” What Einstein meant by this was that for Bohr's theory to gain his approval, determinism would have to prevail in quantum processes. Further sources of difficulty were the methods—those that had worked so well in the case of hydrogen; they were ineffective when applied to the other, more complex elements in the Periodic Table. Bohr knew that he was going to have to revolutionize his thinking. But the job of sketching in the broad outlines of atomic structure for others to complete, and using them to explain the significance of the Periodic Table, had kept him busy for several years, while the rest of the European continent was convulsed by war.

**A French Prince Changes His Studies From Medieval History To Physics.**

While The Great War was turning Europe into a vast slaughterhouse, Louis de Broglie, a descendant of a noble French family, his studies of medieval history having been interrupted by his draft board, found himself thrust into the signal corps, and sent off to study radio transmission. In this manner he acquired a decided taste for science, and after the war he entered into graduate study in physics at The University Of Paris. For his dissertation de Broglie chose a very interesting topic, one that was inspired by a deep mystery associated with the Photoelectric Effect.
You will recall that James Clerk Maxwell and Heinrich Hertz had demonstrated that light is propagated in the form of an electromagnetic wave. Therefore, when we think of light striking a metal surface, we can conjure up an image of ocean waves crashing down upon a beach. We might also be tempted to stretch this analogy further, and to conclude that the amount of energy in the wave is proportional to the intensity of the light—roughly analogous to the square of the height of the ocean wave. But such is not the case. Instead, Einstein found that the energy of the ejected electrons is proportional only to the color, (the frequency), of the incident light.

We can turn down the light’s intensity until it is nearly zero, but the ejected electrons will still possess the same energy as before. There was no ducking it; the effectiveness of the light, in giving energy to electrons, depended only upon the color.

A really crucial observation was made when someone measured the total amount of energy per second arriving at the surface of the metal, and divided this quantity by the number of surface atoms. It was found that if the light energy striking the metal were to arrive in the form of a wave, and if it were uniformly distributed over the surface of the metal, it would take a fairly long time before enough energy would be absorbed to dislodge even one single electron. Amazingly, however, in the laboratory the electrons were emitted immediately, just as soon as the light was switched on. The only way to explain this phenomenon was to say that the quantum of light energy was arriving at the metal in the form of particles!

The game became even more interesting in the year 1922, when a young American named Arthur Compton caused X-rays to impinge upon electrons. Compton measured the energy of the X-rays and the electrons, both before and after the collision. He found to his surprise that the phenomenon could only be explained if he assumed that the X-ray photons also struck the electrons in the form of particles. There was no question about it; light seemed to travel as a wave, but when it arrived, it arrived in the form of a particle, confined to a very small region of space. Therefore, to represent our experiences in a faithful way, we must treat light as if it has a dual nature. Sometimes we can use the wave metaphor; and at other times we must use the particle metaphor. It was this last notion that started de Broglie on a long, fateful train of thought.

The Princely musings went on as follows. This mysterious Being Of Light, the photon, could manifest itself under one line of questioning in the form of a wave, and under another in the form of a particle. The electron on the other hand, had hitherto manifested itself only as a particle. Suppose however, that the electron, too, had a wavelike nature, one that had been hitherto undetected; if so, voilà! This would have fascinating consequences for the atom. For if we were to confine an electron to one of the Bohr orbits, it would be similar to confining a wave to a string whose length was the circumference of the orbit! And as the orbit gets larger, the number of wavelengths it can contain will also increase—in jumps, by one
quantum at a time. What De Broglie envisioned was an arrangement that looked like the one in we have in figure 9-3. (above).

By comparing the Bohr quantum condition with the stipulation that the orbital circumference can accommodate only integral numbers of waves, de Broglie discovered that the wavelength associated with a particle is inversely related to its momentum: that is, as the momentum increases, the wavelength gets smaller. The most important part of this result is: the more accurately we know the wavelength of a quantum object, the more accurately we will be able to determine its momentum: the one being an inverse measure of the other. De Broglie himself went on to visualize the electron as being related to its wave in a manner analogous to the way an ocean liner is related to the tugboats that push it about in the harbor. Therefore, the wave, for de Broglie, was a kind of “pilot wave”, while the electron itself remained, for him, a classical, discrete, Newtonian object. In his heart, De Broglie was to remain a Newtonian to the very end of his long life.

In November 1924, when he submitted his dissertation, the reaction of de Broglie's committee was a blend of stony Cartesian skepticism and blank, total non-comprehension. It had all been too bizarre. Paul Langevin, the committee chair, finally decided that the matter should be submitted to Albert Einstein, a notoriously eccentric genius, for his opinion. Einstein took a liking to de Broglie’s theory immediately; for he saw in it a way out of the dilemma he had helped to create in 1905 with his unorthodox interpretation of the photoelectric effect. Perhaps de Broglie could light the way back from this abominable discontinuity of energy levels and all this unpredictable quantum jumping, back to the One True Faith: that of continuity and determinism—the Newtonian Myth. When one of the members of de Broglie’s dissertation committee had asked him how one would go about determining the wave nature of the electron, the Prince replied tersely: “By focusing a beam of electrons onto a crystal of metal”. Curiously enough, during the following year two researchers at the Bell Telephone Laboratory in the
United States, Davisson and Germer, men who apparently had never heard of Louis de Broglie, happened by coincidence to be working with an electron beam; and when they focussed the beam upon a mass of powdered nickel, they found themselves staring at an interference pattern, that tell-tale badge of wave motion. There it was! The electron really behaved like a wave!

**An Austrian Professor Has A Romantic Adventure And Discovers The Correct Equation.**

After reading de Broglie's dissertation, Einstein relayed the news to Erwin Schroedinger, a 38-year-old Viennese who held a professorship at Zurich. Surprisingly, Einstein was never really fluent in mathematics, (if you are a genius, it's not necessary). But he knew that Schroedinger, a mathematical virtuoso, would be just the man for the job—the job of creating a mathematical description of de Broglie's waves. Schroedinger realized that he had just been given the ingredients for describing the motion of those elusive “matter waves”, as the electrons were then called. When, in the winter of 1926 a colleague extended to him the use of a chalet in the Swiss Alps, he accepted the offer with some alacrity, for the Herr Professor also had a secret romance on his agenda, and that secluded chalet would serve his purposes to perfection. After some time had elapsed, a somewhat disheveled Schroedinger emerged from the Chalet, carrying in his hand the the famous equation that bears his name. In the course of his voluptuous holiday, he had found a way to show how de Broglie’s “waves of matter” could move in a strictly deterministic fashion, under the influence of various forces.

This result was extremely pleasing to Einstein, a believer in Continuity and Determinism, a man who had found quantum jumps to be very unsettling. Einstein had desperately wanted the electron to be something smooth and continuous, just like a wave, and Schroedinger's result seemed almost too good to be true. But actually, there were implications concealed in Schroedinger's work that would continue to haunt Einstein for the rest of his life.

**Two Theories: Too Much Of A Good Thing?**

Word of Schroedinger’s accomplishment was swiftly transmitted to Niels Bohr at his institute in Copenhagen, where the news of Schroedinger's theory had an electrifying effect upon everyone, for Bohr had already been talking with a young German named Werner Heisenberg, who had also been working on the problem of the quantum. Heisenberg had produced an esoteric theory, which predicted the results of quantum measurements by means of manipulating certain creatures from the world of abstract algebra—devices called “matrices”. Before the work of Heisenberg there had been no coherent theory of the quantum; but now there were two theories—ones which did not seem to resemble each other in the slightest. What could one make of this?

As the year 1926 wore on, new developments were occurring on an almost weekly basis. Soon Erwin Schroedinger was able to demonstrate that his version of “quantum mechanics” was really equivalent to Heisenberg’s. Heisenberg, working in Goettingen "at his end of the tunnel," with the help of his mentor, Max Born, showed that his matrices could be thought of as representing (standing for) various measurement processes, such as the measurement of the position or momentum of a particle. It was at this point that the famous Heisenberg Uncertainty Principle was discovered. This Principle says the following: if we wish to observe, say, the location of an
electron, we have to shine light upon it. A low energy photon will not disturb the electron much, but it will also not permit us to see the electron very clearly. A high-energy photon will enable us see the position of the electron in sharper resolution, but it will also impart an indeterminate quantity of momentum in colliding with the electron. Thus, according to Heisenberg’s original formulation of the Principle, a measurement of the one quantity precludes the receipt of information about the other, but as he saw it, this was simply a result of the disturbance of the electron’s motion. The new discovery, however brilliant it was, turned out to be insufficient; it was only the tip of a conceptual iceberg. For when Heisenberg paid a visit to Copenhagen, Niels Bohr was waiting for him with news of the utmost importance.

What Bohr had to say was this:
• It is the act of measurement of a property of a quantum object that actually bestows that property upon the object; there is no way to separate the property itself from the measurement of that property! This idea sounds the death-knell for radical atomism.
• No measurement, no property. How can we talk meaningfully about a property that we never measure? Position and momentum are intrinsically incompatible properties, because they are obtained by methods of measurement, ones that are physically incompatible with each other.
• You can’t obtain a measurement of position, once you have at the same time, measured the momentum, and visa-versa. This result has become known as:

**The Principle Of Complementarity.**
• Position and momentum are “complementary” quantities. Such quantities are mutually incompatible, but both are essential, for neither one nor the other, taken alone, gives a complete description of the state of a quantum system—thereby giving a description of the world.
• Therefore it makes no sense to ascribe a position or a momentum to a quantum object if an appropriate measurement has not taken place.

To say that Heisenberg found this idea upsetting is an understatement; he was actually in tears. In fact, he and Bohr nearly had a falling-out over it. In later years Heisenberg described his feelings at the time:

> I remember discussions with Bohr which went through many hours till very late at night and ended almost in despair, and when at the end of the discussion I went alone for a walk in the neighboring park I repeated to myself again and again the question: “Can nature possibly be as absurd as it seemed to us in these atomic experiments?”

Later discoveries revealed that there was no way to construct a Schroedinger wave that could be said to represent directly a particle such as an electron, for instance. It had long been known that an appropriate superposition (a “bunching up”) of Schroedinger waves could indeed be constructed, something that looked like a sharp spike in space. But it became disappointingly clear to Einstein and the wave enthusiasts that this spike would quickly dissipate, spreading out through all space. However, a radical suggestion was to come from Professor Max Born from his laboratory at the University of Goettingen. Just what this suggestion was, is something that we shall learn presently.

It was now the year 1927. Fourteen years after his historic paper on the hydrogen atom, Bohr’s
quantum philosophy had finally jelled, and none too soon, either. In October of that year there would be a time of testing; for then would come the first great confrontation with Einstein, leader of the Continuist, Determinist Faction--The Old Guard. The year 1927 was really the year of the Storm—a Storm that eventually washed away the old intellectual order.

And by the end of the year 1927 the outlines of quantum physics were just beginning to be clear. In the words of physicist-philosopher Bernard d’Espagnat:

...whoever tries to form an idea of the world, and of man’s position in the world,—has to take the findings of quantum physics seriously into account.

Notes:
(1) An alpha particle is the charged nucleus of a helium atom. These occur in the course of the radioactive decay of large atoms. It just turned out that Rutherford was the world authority on the subject of radioactive decay. Thus he was ideally placed as an actor in the play.
(2) If we were to put a hydrogen nucleus together with its orbital electron at 9 AM, according to the classical theory the entire structure would last for a mere $10^{-9}$ seconds, by which time the electron would have spiraled irrevocably into the nucleus. The world would never make it to 9:01 AM on the day of creation; nor would there ever be anything left to record its demise. That this doesn’t happen is well, self-evident.
(4) These thin bands are really called “lines”. They occur because the light from the glowing gas is passed through a narrow slit. The “lines” are really images of the slit, either captured on a photographic emulsion, or just displayed upon the wall of the laboratory.
(5) Actually Rydberg’s constant is not given in terms of the frequencies of the light, but rather in terms of something called “the inverse wavelength”, a quantity dear to spectroscopists.
(6) As the respected scientist Sir James Jeans had remarked, the only justification for Bohr’s assumptions was “the very weighty one of success”. But the phone call that came through from Stockholm was real enough; Bohr was duly awarded The Prize in 1922.
(7) There is even a Latin proverb: Natura non facit saltum: “nature makes no leaps”. Little did they know…. Now is a good time to look back at Galileo’s analysis of projectile motion, in Chapter Two.
(8) World War I, called the Great War, broke out on 3 August 1914, and lasted until an armistice was declared in 1918. World War II was essentially a continuation of World War I.
(9) Actually, the problem is somewhat more complicated than this. Both Einstein and Compton treated the problem as if the photons were arriving one at a time. In fact, at that time it was impossible to control the number of photons being produced, but no one was aware of it. 80 years would pass before a completely rigorous demonstration of the quantum nature of the photoelectric and Compton effects would be possible. Fortunately, no one realized this at that time. Strictly speaking, Einstein did not really demonstrate the existence of the photon, but his guess was still right.
(10) As Malory coyly remarked about the tryst between Lancelot and Guinevere, (in La Morte d’Arthur14th cent.) “I know not what they did there, for then their customs were different from ours”. The woman who made such a distinguished contribution to science seems destined to remain forever anonymous.
(11) It is this idea, central to the Copenhagen Interpretation, that led to Heisenberg's terse dictum: "An atom is not a thing".
CHAPTER TEN
THE WAR OF THE WORLD-VIEWS

There may be no such thing as the glittering central mechanism of the universe...Not machinery but magic may be the better description of the treasure that is waiting.
John Archibald Wheeler.

What Was At Stake--Both Then And Now

We have seen that from the time of Galileo, Descartes and Newton to the early twentieth century, a certain scientific and philosophical outlook had emerged in Europe and North America, one that had attained dominance. This outlook contained certain central themes:

• Determinism: The past determines the future, without exception. Any element of chance that seems to be present in any event, is only a manifestation of our lack of information.

• Continuity: In moving from one place to another, a material object successively occupies all intervening points in space. These points are packed together with infinite density.

• Causality: Every event that takes place can be thought of as the necessary result of one or more previous events, called "causes."

• Objectivism: Realism--the idea that when we (or the universe) measure(s) or observe(s) a quantity, that quantity is something that is already "there."

Even today, at least 99 out of 100 persons imbued with the culture of Modern Civilization, would consider self-evident the propositions described above: "they stand to reason." But as we shall see, not one of them seems to hold up under close examination. Although these four themes have their roots deep in the Western Philosophical Tradition, their fruiting was delayed until the time of the Scientific Revolution. It was the triumph of Newtonian mechanics, to have melded them together in a definitive pattern; one which scientists went on to employ in the same manner as a team of tailors; a pattern of behavior which we can express in the following way: “Do you remember how we solved that other problem? Well, good! Then we’ll solve this one in the same way”. When such a pattern becomes entrenched, and linked with other compatible patterns, we refer to it as a Paradigm --"a pattern of patterns." This is what began to happen at the time of the Scientific Revolution, and it became what is sometimes called the Newtonian-Cartesian Paradigm. Philosophers Martin Heidegger and Edmund Husserl have referred to the paradigm as The Cartesian Project. We shall discuss this further in a later chapter.

As more and more problems fell before the onslaught of scientists using their new weapon, the Newtonian Method, over time the hypnotic power of the Newtonian Mechanistic Myth became immense. For more than two hundred years it produced a degree of enthusiasm akin to religious fervor among western thinkers. The list of its devoted apostles included such illustrious figures as: Voltaire, Helmholtz, Maxwell, Boltzmann and Freud.
The Mechanistic Myth

The mechanistic myth goes like this: Imagine some kind of isolated physical system under the known influence of what we shall simply call simply: External Forces. Suppose that, besides knowing the Forces, we know the position and velocity of all of the particles in the system at some initial moment in time. Then as time cranks smoothly, continuously forward, all the particles will also move smoothly in their trajectories. To be able to predict all future configurations of that system, forever\(^1\), all we have to do is apply Newton’s laws of motion to the system. Next, we have to recognize that the Universe itself is a physical system. Its future was therefore considered predictable--hence controllable. According to this scheme, we could (in principle) predict the future of the Universe. Louis de Broglie then, with his theory of waves, was merely upholding the doctrine of Continuity, to keep it from being washed away by a sea of discontinuous quantum jumps. His electron, towed along by its pilot wave, and obeying Newton's laws, would be able to find its deterministic way unerringly to the target. Naturally, an arrangement of this kind must have delighted Einstein, who was determined to uphold the religion of the Newtonians. But what about the waves themselves? How could they be described mathematically? How could one use this kind of idea to predict the point where the electron would actually land? Against what strange shore did those pilot waves break? Schroedinger had found a way to show how his “waves of matter”\(^2\) would move in a deterministic fashion, under the influence of various forces. Einstein, although he had been one of the original founders of the quantum theory, was quite uneasy about the direction that his original line of inquiry had taken. For the moment, though, he believed that in Schroedinger, he had at last found his champion. To be sure, there was still some uneasiness here: Schroedinger had already shown that his “wave mechanics” was mathematically equivalent to the far more radical formalism developed by Werner Heisenberg. Further, it was Heisenberg’s reasoning that had led directly to the Uncertainty Principle—a discovery that was already leading to chilling revelations in Copenhagen--revelations that were chilling for Einstein, to say the least.

Heisenberg And Uncertainty

At this point it is worthwhile for us to examine the Uncertainty Principle in more detail, partly in order to gain an insight into what happens when we actually make a measurement, and partly to
discover the extent to which we must change our way of thinking, to accommodate The Principle. What Heisenberg had found was, that the act of measurement could be regarded as a kind of “operation”—something to be represented by a mathematical artifact called an “operator.” As an example, the act of pulling on your socks is an “operation”; so is the act of putting on your shoes. But if you were to perform these operations in the reverse order, we will all agree that the final results would be vastly different. (People would look at you, and they would talk). A mathematician would say that the two operations “don’t commute”. The same thing is true of measurements of position and momentum; the respective measurement operations don’t commute with each other. To obtain an infinitely “sharp” value of the position requires that the quantum object should take on every possible value of the momentum; and vice-versa. As we have seen, it was Niels Bohr, with his uncanny instinct, who saw the consequences of Heisenberg’s reasoning. Since the act of measurement was necessary to produce, say, the position of the quantum object, what could it mean for the quantum object's position even to exist in the absence of a measurement? His answer was: It means Nothing at all!

When we make measurements, such as those of position $x$, or momentum $p$, we don’t always get the same values. Instead, we get a statistical distribution of positions or momenta. So we say that there is a “spread” in their values. See figure 10-1, above. What the Heisenberg Uncertainty principle says is that when the spread of position measurements is small, the spread of momentum measurements will be large, and vice-versa. Therefore the two spreads are inversely related to each other. Physicists express the position-momentum Uncertainty Principle algebraically like this: 
$$\Delta x \Delta p \sim \hbar/2\pi.$$

What this expression says is that the spread in $x$ times the spread in $p$ is about the size of $\hbar/2\pi$, where $\hbar$ is Planck's constant. Furthermore, the “spreading” is not the result of any human error; instead, it is inherent in the Very Nature Of Things. This result was certainly unsettling to Einstein and the Continuist faction, as was also the idea of electrons jumping non-deterministically from one orbit to another. It negated the philosophical foundations of classical physics. It was heresy!

Still, Schroedinger initially found himself, together with DeBroglie, in Einstein’s camp, the camp of the Continuists. After all, it was his wave that supposedly guided de Broglie’s deterministic electron. But what he thought he had done, and what he had actually done, were really two very different things, for there were disturbing surprises in store. For one thing, let us ask the question: did the wave represent the electron itself, or was it really something else? True, it is possible, by adding waves of varying wavelengths together, to get a kind of wave form that is all bunched tightly, spike-like, together in one place in space. But is this what the electron really is? We have seen earlier that, to the disappointment of Einstein and the wave enthusiasts, this "spike," according to Schroedinger's equation could be shown, in a short time, to dissipate, spreading uncontrollably out through all space—a most un-particle-like form of behavior! Therefore, we must conclude that there is no way to construct a Schroedinger wave that can also truly be said to represent directly a "particle" (such as an electron). If it does not represent a particle, what, then, does it represent? For an answer, see below. Schroedinger had his own reasons to doubt Einstein’s interpretation of his equation. The mathematical apparatus of Schroedinger’s equation does not refer to the kind of space we imagine ourselves to inhabit. Instead, it refers to an abstract space called “configuration space”, one that is multi-dimensional. This mathematical abstraction carries with it certain disturbing practical consequences. Whenever two quantum particles become involved with each other, their wave functions become permanently “entangled.” This effect marks a decisive, even
radical departure from classical behavior; and it is, in effect, crucial to the Quantum Theory. Schroedinger realized instinctively that this result was no mere artifact of the mathematics, but instead, that it hinted at a fundamental difference between quantum and classical thinking—a chasm vast, and forever unbridgeable⁴. Then, what are we to make of this Schroedinger wave? A strange, but very persuasive interpretation⁵ came from Professor Max Born of The University Of Goettingen. An idea that is consistent with all of the observations, said he, is that the square of the height of the Schroedinger wave can be thought of as the probability of our locating the particle within a given small volume of space⁶. "The probability!," you say "But I thought the wave was supposed to be deterministic!" To which I reply: "That's right. The particle's path is non-deterministic, but the probability of finding the particle in space and time is deterministic. A definite: “Maybe.” Then Schroedinger’s wave is not even a particle, but rather it is a measure of the probability of locating a particle at a point in space when a measurement is being made—in other words, a measure of the available information! Information available to whom or to what? At this writing, three-quarters of a century have gone by, and the answer has never been completely clear. It was this amazing development, which caused the physicist Sir Arthur Eddington to exclaim, that: "The stuff of the world is mind-stuff."

Then we are driven to the conclusion that Schroedinger’s equation must be a description of the evolution of the probability— with respect to time! According to Born, the act of measurement is in a sense an act of destruction; it somehow causes the “collapse of the wave packet”, the Schroedinger wave, and its immediate replacement by a classical event—an event occurring at a single point in space-time. It is an abrupt discontinuity in the amount of available information. Once again, we have a delightful irony. The deterministic faction had wanted to find a truly deterministic equation. And just as they seemed to have one, Nature had played a dirty trick; for the only entity that was propagating deterministically was the probability of locating the quantum object. And a probability is not a thing, like a table or chair. It seems to be a creature whose exclusive habitation is the mind. But whose mind? Thus, quantum probability was, for Einstein, a worst-case scenario.
The Fifth Solvay Conference: Preliminary Skirmishes.

Ernest Solvay, a Belgian industrialist with a strong interest in science and a philanthropic bent, had endowed a series of scientific conferences. These conferences played an important part in the story of the Quantum Theory, and the story of the upsetting of our classical view of reality. This was the background to the famous Fifth Conference, which began on Monday, 24 October 1927. Although the Conference bore the innocuous title: *Electrons and Photons*, everyone knew what was to be its real business: it was to be a showdown between the Old and the New. The chair at the Conference was the venerable Henryk Antoon Lorentz, the great Dutch physicist. After some preliminary sparring, Louis de Broglie spoke, describing his theory of the pilot wave. But when "certain difficulties" were mentioned, the poor man even began to doubt the validity of his own theory, and was forced to retreat from his position. After de Broglie, Born and Heisenberg spoke, presenting their paper on "matrix mechanics," the arithmetic of operators. They concluded their lecture with a description of the Heisenberg Uncertainty Principle, and with the following words, they threw down the gauntlet before the Continuist faction: “The real meaning of Planck's constant $\hbar$ is just this: it constitutes a universal gauge of the indeterminism inherent in the laws of nature owing to the wave-particle duality”. Heisenberg illustrated his idea with the following kind of picture: fig. 10-2.
To understand the meaning of this statement we need to imagine a graph, in which we plot momentum along the vertical axis, and position along the horizontal axis. The uncertainties inherent in the position and momentum can be described by visualizing a rectangle. In the one extreme it is tall and skinny when the position is well defined, or at the other extreme it is short and fat when the momentum is well defined. But in every case the area of the rectangle, the product of the uncertainties, remains fixed, and that product is: Planck’s constant $\hbar$, divided by $2\pi$.

Born and Heisenberg concluded with the words: “We maintain that quantum mechanics is a complete theory; its basic physical and mathematical hypotheses are not further susceptible of modifications”. This was, as they say, a way of giving their opponents "The Cut Direct". It meant the following: “Our theory is sufficient to predict the outcome of all quantum-mechanical experiments; everything else is either superfluous or just plain wrong.” It is a matter of fascination to me to reflect that this happened before I was born, and now I am 86 years old. It was revolutionary then, and even today, although scientists make constant use of these ideas in the laboratory, it is very hard to make them central to anyone’s world-view.

The next speaker was Schroedinger, who described his work on “wave mechanics”, stressing the difficulties, the entanglements that arose when more than one quantum state was involved. The Schroedinger wave has a kind of holistic character to it; but once the final measurement occurs, this character abruptly vanishes, and a classical result occurs--one that is not described by his equation. What Schroedinger was getting at was disturbingly clear: he was not at all comfortable with the idea that his Schroedinger wave described the behavior of an actual particle. And of course this was immediately interpreted as giving aid and comfort to those in Bohr’s camp. If there had been a rooting section, a cheer would have gone up.

Lorentz, the gentle patriarch, a man who would not live to see another year, was visibly disturbed by what he was hearing, for the paradigm of the Newtonians had also been his. It was a crisis of faith! He spoke plaintively, saying:

I would always want to retain my determinist faith ... in fundamental phenomena. Is it that a more profound intelligence could not account for the motion of these electrons? Must they necessarily require indeterminism in principle?
These words epitomize the anguish felt by many, even today, at the spectacle of the breaching of the Newtonian Reality, the slow, creaking collapse of the Newtonian-Cartesian paradigm. Wearily, Lorentz invited Niels Bohr to come to the podium to address the meeting. In his usual maddeningly discursive way, Bohr then proceeded to sketch out the outline of the framework of his revolutionary Principle Of Complementarity. After some further discussion by two minor figures, there then came the electrifying moment that everyone had been waiting for. First Max Born rose, and addressed Albert Einstein: “Mr. Einstein once considered the following problem: a radioactive element emits alpha particles into all directions; these are made visible by means of a Wilson Chamber. If, now, a spherical wave is associated with every act of emission, how can it be understood that the trace of each alpha particle appears as an almost straight line? In other words, how can the corpuscular character of a phenomenon be reconciled with its representation in terms of waves?” Born then proceeded to give his own interpretation: the collapse of the wave packet, and after a few further remarks, yielded the floor to Albert Einstein. The tension was electric. “I must apologize,” Einstein said, “for not having gone deeply into quantum mechanics”, (a ripple of nervous laughter in the hall). “Nevertheless, I would like to make some general remarks”. The following treatment was masterful—one that continued to attract supporters for decades afterward. First he pointed out that we can consider the Quantum Theory from two different viewpoints. For clarification he described the following experiment. A particle, such as a photon or an electron, impinges in a perpendicular fashion upon a diaphragm having a small circular hole bored through it. In this way we can think of the Schroedinger wave as being “diffracted” in the hole. Emerging from the hole, the diffracted beam strikes a hemispherically-shaped sensitive screen (similar to the one used by Ernest Rutherford in a previous chapter), which will show the point of arrival of the particle.

![Figure 10-3](image)

The intensity of the diffracted spherical wave at a point of the screen will be proportional to the probability that the particle will arrive there. Of course this hemispherical screen is placed in such a fashion that, at the center of the hemisphere, is the hole to which we have referred. See figure 10-3 above.

**Viewpoint One.** This view is one that is typical of the method used by the insurance company’s actuary. The Schroedinger wave does not describe the probability of finding an individual particle in some small region of space, but it rather describes the behavior of an “ensemble” of particles: the density of a swarm of them. This argument is identical with the manner in which your insurance premiums are computed. The actuary looks at the computerized data for all people in your age group, makes a substantial correction for whether you smoke cigarettes and ride motorcycles, and comes up with a figure. The underlying assumption is that there are always unknown determining factors, such as genetic ones, to which they hope to gain access tomorrow, or the next day--the
probability is merely an expression of our ignorance of something that is already there. Similarly, Einstein visualized that the particles themselves may have “wheels within wheels”, although these may be hidden from us at this point in time. How else could you explain the fact that the particles passing through the hole didn’t all end up in the same place? In time, a name was found for this hypothetical phenomenon: it was called: Hidden Variables. It is the notion that we still live in a clockwork 17th century universe; but we just can’t see the clockwork. If we could see it, then we would know—or so Einstein thought.

**Viewpoint Two.** According to Viewpoint Two, the quantum theory is a complete theory of individual processes; it doesn’t talk about swarms. It is the only answer that can be given to the question: "What is the state of the particle?" The uncertainty already resides in the quantum nature of the particle. Each individual quantum entity traveling to the diaphragm can be described as spread out into a “wave packet” which, after being diffracted at the hole, finally arrives at a certain point \( P \) on the hemispherical screen. The square of the amplitude of the Schroedinger wave: \[ \Psi(r) \] expresses the probability that at a given moment in time, the particle described by that wave packet can be found at some intermediate distance \( r \) between the hole and the screen. If the probability is interpreted according to Viewpoint Two, then, in the absence of any attempt to intercept the particle before reaching the screen, the particle must be considered as potentially present with constant probability over the entire area of the screen. However, as soon as the particle has been detected at a given point, a peculiar action-at-a-distance kind of thing must take place, forever precluding the detection of the particle at any other point. The underlying assumption here is that there aren’t any extrinsic unknown factors. Although it seems that Einstein did not express the matter in quite this way, at the back of his mind must have lurked the following consideration: “Let us suppose that the hemispherical screen was at a long distance from the hole, and therefore very large. Then, when the particle is detected at a given point on the screen (call it A), how will the signal, bearing the news of its arrival, reach all of the other points on the screen, some of them far distant, telling them to collapse the wave packet, that the photon has already arrived, without at the same time violating the Special Theory Of Relativity, which limits the speed of information transfer to the speed of light?” We will find that this latter consideration was to arise eight years later, when Einstein made his final attempt to unseat Bohr’s version of the Quantum Theory. In any event, Einstein\(^{11}\) made it clear that his sympathies lay solidly with Viewpoint One, and that Viewpoint Two was, for him, an abomination. Although Einstein’s keen intuition went straight to the heart of the matter, neither he nor Bohr was able to resolve the problem. The rest of the physicists returned to their laboratories and proceeded to employ the quantum mechanics derived from the theory of Bohr, Heisenberg and Schroedinger to solve every problem that they could think of, while Bohr and Einstein continued their fateful dialogue. The watchword for young physicists at the time was: “Don’t ask what it all means. Just shut up and calculate.” How long did this ridiculous state of affairs last? For more than a half-century!\(^{12}\)

But to understand the course followed by the discussion, we must first return to the famous Two-Slit experiment of Thomas Young, the one that led to the creation of the wave theory of light. This is a necessary pilgrimage, for every quantum mechanical conundrum is like unto this one! It is fair to say that the Two-Slit experiment lies at the very heart of Quantum Reality.
The Celebrated Two-Slit Experiment Revisited

This time we want to leave open the possibility that, in addition to bombarding the slit with light waves, we can also perform the experiment with other projectiles, such as machine-gun bullets or electrons.

1) In The Case Of Machine Gun Bullets.... Imagine the following scenario. At the left side of the diagram is mounted a horizontal array of machine guns, belching a stream of bullets through a narrow slit in a steel plate, against a second plate of steel, located a moderately long distance away from the first one; the second plate is pierced by two more slits, separated by a short distance from each other. Behind this second plate, to the right, is located a kind of backstop, one which absorbs all the bullets which strike it. If we fire the machine gun for a while, a pattern of bullet-holes will become visible on the backstop. If we count the distribution of bullet holes as a function of the position along the backstop, we will get a pattern that looks something like this: (see figure 10.4): The spread of the bullet holes into that region of the back-stop which is out of the direct line of fire is due, of course, to the ricocheting of the bullets against the edges of the slits. That is the way bullets behave. (‘Tis their nature).

Figure 10-4

2) Waves, (such as water waves). This time let’s imagine a kind of water tank. At the left side of the diagram we mount a wave generator—maybe a kind of vibrating instrument, one which agitates the surface of the water, producing waves which go through a first slit, and advance to the right, until they impinge upon a plate pierced with two more slits. Behind the plate, (that is, to the right of it) is a screen, on which we can measure the square of the height of the water waves. If we measure this quantity as a function of the position on the screen, we will get a pattern that looks like this:

Figure 10-5
3) “Quantum Particles”, (think of electrons though photons are also quantum particles; but electrons have mass, and we used to think of them as little balls). This time, at the left side of the diagram, we are going to have an electron gun. (This is not fanciful; your TV set has one). In front of the electron gun is a plate with a single small horizontal slit. At a distance to the right is a second plate, pierced by two more slits. The electron beam goes first through the single slit; then it progresses to the right, impinging upon the second plate, with its two slits. Behind the second plate is a screen, along which we can slide an electron detector (a Geiger tube would do). We move the detector across the path of the beam, counting electrons as we go. If we plot the number of electrons per second as a function of the position on the screen, we will get a pattern that looks like this.

![Figure 10-6](image)

This last result should come as a surprise. For surely we expected the electron to behave like a BB-shot; after all, it is supposed to be a particle; but it seems that nature has somehow “played us false.” The individual electrons indeed arrive at very definite points on the screen. We can even turn down the intensity of the beam until the electrons arrive one at a time, and listen to the individual electrons as they discharge the Geiger tube. But no matter; for eventually our plot of electrons/second versus the distance along the screen will still bear a suspicious resemblance to Fig. 10.5! If we employ the kind of thinking that we habitually apply to material objects, we will say: “The electron had to pass through one slit or the other. After all, that’s the way it is with cars on roads and people going through turnstiles. So what is the meaning of this crazy wave-like interference?” If we ask the question: “Which slit did the electron go through?”, we would be tempted to place detectors at the respective slits; so that we might be able to trace our quarry all the way to the target. But when we try to do this, the interference pattern promptly disappears from the screen, and we get a reprise of Figure 10.4, and the quantum objects, (electrons, etc.) act just like bullets, cars or people. This is the result of the quantum two-slit experiment. The great physicist Richard Feynman described it as a phenomenon “which lies at the heart of quantum mechanics; in reality it contains the only mystery” of the theory, one that cannot be explained in any classical way.

**The Long Duel Between Einstein And Bohr.**

They were lifelong friends: Bohr and Einstein. The pattern was always the same: Einstein would produce a brilliant conundrum challenging the validity of the Copenhagen Interpretation of the Quantum Theory; and Bohr would counter by bringing forth an even more brilliant solution. Thirty-five years later, after his sudden death, his co-workers discovered that Bohr had reproduced one of the diagrams that he had used more than twenty-five years before in this duel with Einstein, there on the chalkboard at his Institute. Apparently he had been pondering over the problem, down to his
Notes to Chapter Ten:

(1) At the time of Napoleon there lived a famous scientist, Pierre Simon de Laplace (a kind of Carl Sagan of those times). Laplace was adored in all of the politically correct salons. He once imagined that there is a demon, (a kind of computer), who can compute all of the positions and velocities of all of the objects in the universe. If we allow, (if not by fact, but by hypothesis) that the nature of the forces might be knowable, the demon can predict all future occurrences, to the end of time, and retrodict all past occurrences, to the beginning of all beginnings. But Bohr put Laplace’s demon permanently out of business.

(2) At one time it was considered chic to refer to Schrödinger’s brainchild as a “wavicle”, thereby sidestepping the need to realize that the Schrödinger function does not describe any material object, but rather the probability of finding one. I’m old enough to remember that time!

(3) This is called “forming a superposition”—any irregular-looking wave pulse, any curve, like a breaker in the instant before it strikes the beach, can be thought of as a superposition of sine waves.

(4) Besides, Schrödinger’s wave can describe systems containing more than one object, say, N objects. Such a wave propagates in an abstract multi-dimensional space, (with 6N dimensions!) But the particle, when it finally appears, is located in the customary 3-dimensions plus the time. Measurement, (observation) seems to produce a radical diminution in the number of relevant dimensions. Remember, I warned you that this would be strange! *Esse est percipi.* (To be is to be perceived!)

(5) Born’s interpretation has stood the test of time, however. It has never been contradicted by laboratory measurements. For 87 years it has withstood all challenges. The Quantum Theory is the Champion Scientific Theory for all time.

(6) Life abounds in delicious ironies. According to Max Jammer, to whose treatise: *The Philosophy Of Quantum Mechanics*, John Wiley & Sons, NY, 1974, I am indebted for much of the material in this chapter, in a lecture delivered in 1955 Max Born declared that it was Einstein’s idea which he (Born) applied in 1926, to interpret Schrödinger’s wave function in terms of probability! Of course this is the same interpretation that Einstein later opposed so eloquently.

(7) This is a euphemism for: “His views were vigorously attacked”.

(8) Bohr’s position was that knowledge of one aspect of reality will always exclude knowledge of some other complementary aspect; but that both aspects are necessary to give a correct description. This idea, in his mind, was of far more general applicability than to Quantum Theory. See *Thematic Origins Of Scientific Thought*, by Gerald Holton, Harvard University Press, Cambridge, MA, 1975, p115, *The Roots Of Complementarity*.

(9) The reference here is to a device called the Wilson Cloud Chamber. It contains a gas whose volume is suddenly expanded. Charged particles passing through the gas will then leave trails of condensation droplets, analogous to the “con-trails” left by jet planes. We do not see the particles, of course; we see only the droplets: condensation events. *When we look for objects, we only find events*!

(10) When a wave of any kind passes through a hole, we can describe what takes place by thinking of the hole as acting as the source of a new wave—one which will spread out in the shape of a hemisphere. This phenomenon is called “diffraction”.

(11) What an incredible man was Albert Einstein! Even when he was wrong, his insights still proved to be incredibly fruitful.

(12) There is a wonderful book! The title: *How the Hippies Saved Physics*. The author, David Kaiser, is a Professor at MIT. His Introduction and Chapter One, (entitled “Shut Up And
Calculate"), contain a faithful history of my own discouragement as a student, attempting to understand the Quantum Theory. You see, I had thought all along that everybody else understood it, except me! Thank you, Professor Kaiser!

(13) The definitive exposition of this pivotal experiment was given by the physicist Richard Feynman. It can be found in The Character Of Physical Law, MIT Press, 1965, The Quantum Mechanical View Of Nature. Everyone should read the transcript of this brilliant lecture.

(14) I have suggested electrons, because we have been conditioned by our upbringing to imagine them as charged BB-shot or something of the kind. Prepare to be shocked; they’re not like that at all. Anything, in principle, would serve as a quantum particle, but practical difficulties stand in the way.

(15) There is a very important point to be made here. The electrons are always detected in a very localized way, as having arrived in the form of “particles”. But the interference pattern superimposed upon the random dots, gives away the game; it tells us that some wavelike agency modulated the electrons’ path.

(16) It is always risky to make categorical negative statements. The physicist David Bohm has produced a theory that elaborates upon that of Louis de Broglie, in which the electron is a classical particle, guided by a mysterious, undetectable, ubiquitous “quantum potential”. The purpose of the quantum potential is to guide the electron, in much the way an airplane is guided by radio signals. Using this theory, he was able to reproduce the result of the two-slit experiment. But there are drawbacks to the Bohmian theory. In order to guide a particle, it is necessary to expend some energy. It has been impossible to detect this energy to date. We shall return to this subject in a later chapter.

(17) What is meant by a “thought-experiment”? At the beginning of the twentieth century there lived a very influential philosopher named Ernst Mach. Mach was determined that one should speak only of those sensory inputs which could be directly measured. He was even a bit suspicious about the efficacy of mathematics in the description of experience, since mathematics is not a sensory input. At the time, Mach’s rigid way of thought, called Positivism, was very popular, and produced intense loyalty among scientists. But in order to create, it is essential to relax enough to use one’s imagination. Eventually a kind of compromise was effected, by which one could be free to imagine an experiment, even if there were no way to carry it out in the laboratory, on the condition that one specified with some precision, exactly how the experiment would be done. This kind of exercise is called a “thought-experiment”, after the German word: Gedankenexperiment. At the outset of his career Einstein was much influenced by Mach, and used the thought-experiment with great power and originality in developing his Special Theory Of Relativity. But the rapid development of science in the twentieth century soon made it necessary for Einstein to express himself in abstract terms that were progressively more estranged from the concrete approach of Ernst Mach. Thus when it was pointed out to him that the Bohr-Heisenberg approach “was invented by you in 1905,” Einstein replied: “a good joke should not be repeated too often”.

(17) Copenhagen Interpretation: named in honor of Niels Bohr's native city: a great place!
CHAPTER ELEVEN
THE VIEW FROM BOHR’S OFFICE

We want to believe there is some unique way our words hook onto the world and that this hooking, or accurate representation, makes our statements true or false.

Bruce Gregory

Nothing is more important about quantum physics than this: it has destroyed the concept of the world as ‘sitting out there’.

The Universe will never be the same.

John Archibald Wheeler.

In Ancient Assyria the astronomer-priests had developed a method of calculating successive reappearances of the planets; they were most interested in those of the planet Venus. Curiously, at a later point in time, the path of that same planet was also tracked by the Maya--1200 years later in fact, and 10,000 miles distant. Both cultures had evolved elaborate algorithms-- recipes, for predicting its reappearances, without any notion that the planet they were observing might be a material object, made of the same “stuff” as things on earth. Instead, it remained for Europeans like Kepler and Newton who, conditioned by Greek influences, made an audacious (and mostly successful) attempt to force the multifarious phenomena of the celestial world into a pattern that expressed the inevitable outcome of the workings of abstract Cosmic Law; one whereby all planetary phenomena could be subsumed under the same general category as the motion of a projectile.

In the course of the development of the Quantum Theory one could almost believe that the ghosts of the Assyrian and Mayan priests were chuckling quietly over the confusion in the ranks of the best physicists of the twentieth century. For Schroedinger’s Equation also seems to function as a kind of algorithm, a calculational recipe that works--Saves the Appearances--even when we don’t understand what we are doing. And this is precisely the case: at this time, no one knows why the rules of the quantum are the way they are. The great Richard Feynman even felt that the quest for: “Why?” would propel the searcher "down the drain into a blind alley." Most physicists seemed to be content to live with this arrangement without examining it, and confined themselves to applying their new toy to the study of solids, of molecules, of atoms and of nuclei, like teenagers in a stolen car. But other physicists, trained in the Newtonian tradition, and uneasy about this vacuum in their understanding, still tried to create a new Mirror to hold up to Nature. Before conducting a review of some of the most interesting of these nonstandard attempts at interpretation, however, we must first unfold the rich variations of the Copenhagen Interpretation in all their glory; for even the best science fiction is, by comparison, a very thin gruel. And in the end we will find—at last—a mystery.

The Copenhagen Interpretations.

The standard way of expressing the Spirit of Copenhagen is to say that: there is no Underlying Reality. This statement may seem shocking at first—but wait! If all we know is what we experience, whether
directly through our senses, or through their extensions in the laboratory, then we have no right to infer that there is some underlying Nature-in-Itself, one which, while being inaccessible to experience, has features that we can faithfully mirror. After all, as seems to be the case, our conceptual apparatus is tied firmly to our sensory motor system. From this, our human inheritance, we cannot legitimately appeal to any external authority. The complete version of Niels Bohr’s famous quote on the subject is:

There is no quantum world. There is only an abstract quantum description. It is wrong to think that the task of physics is to find out how nature is. Physics concerns only what we can say about nature.

As outlandish as this statement may sound, it is a doctrine to which the majority of physicists adhere, (when they think about the matter at all). Further, it must be admitted that there is a kind of minimalist decency and modesty to it. The longevity of the Copenhagen Interpretation is due partly to the fact that it does not make outlandish ontological claims, which go beyond the observed facts. There exists another, only slightly amended, version of the Copenhagen Interpretation. It asserts that the only Reality is “phenomenal”—that which we actually experience. We could call it “Quantum Realism,” or: “Observation equals Reality.” But since we only know what is observed, we are driven to conclude that Reality is created by Observation. Today the doyen of this school of thought is the redoubtable John Archibald Wheeler, a man who has produced aphorisms such as this one:

No elementary quantum phenomenon is a phenomenon until it is a registered phenomenon.

Copenhagen I Under Closer Scrutiny

However, a nagging question arises. Where does a phenomenon go to register? To understand better the problem of “registration”, or better: the problem of: What is Observation? We need to review the Copenhagen Recipe in a more detailed manner:

• The particle’s wave function evolves deterministically with time, according to Schroedinger’s Equation. Thus the wave function behaves like a Newtonian object—except that it is not an object; instead it is a kind of probability—and not merely the probability that the quantum object will be in a given region; rather, the square of this wave function is a measure of the probability of some measuring device’s finding, and registering the quantum object in a given region in space. The act of Observation is inseparable from The Event itself, for all we observe is events!

• We never observe this wave function directly. Instead, we always observe a severely localized interaction, for which we employ the metaphor: “particle”. For example, if we use a piece of photographic film as our target, we can see a tiny spot, corresponding to the conversion of a few molecules of silver bromide into atoms of metallic silver, accompanied by a tiny puff of bromine gas. This, the Observation, is not described by Schroedinger’s Equation. Apparently an abrupt, and very mysterious discontinuity occurs whenever an Observation occurs. It is this mystery that has been a source of continual dissatisfaction—for some people, and of puzzlement to everyone. One hard-headed quantum physicist calls it "the abyss."

• Observation produces a discontinuity, called “the collapse of the wave packet”; and it is absolutely necessary for this event to occur, so that something can actually be said to be observed; and therefore that it can be said to have happened. To happen is to interact. But the observing apparatus is necessarily a macroscopic one: a human or possibly some kind of “black box” with dials on its face—or
even some other part of the universe, reacting with the quantum object. Moreover, the measurement that is made is always one of some property such as: position or momentum—categories used, and made familiar by Newton. These categories seem to be real to us because they are tied to our sensory-motor apparatus. Hence the actual results of the observation of a quantum system must still be registered on macroscopic pieces of apparatus, as classical events.7 A strange kind of gateway seems to connect the “World Quantum” with the “World Classical”. But the latter is only a consequence of the former. It is the "World Quantum" that is fundamental.

• This latter idea is, to put it mildly, puzzling; for it implies that the classical measuring apparatus is inseparable from the act of quantum observation. Also, it neatly destroys the subject-object dichotomy so dear to every scientist since the time of Newton, a dichotomy built into the structure of our language. For how can you observe an object, except in terms of the apparatus that you choose? To make an observation, you must exercise an option, namely: What Property To Observe? There is no evidence to support the notion that the measured property has any reality independent of the act of measurement i.e., that it was there before you arrived! It is this option which singles out the characteristic of the electron, (or any other quantum creature), that will manifest itself to our probing. Your choice of what to observe is inseparable from the observation itself. Bohr expressed this idea in the following manner:

Isolated material particles are abstractions, their properties being definable and observable only through their interaction with other systems. (Ah-hah! The death of radical atomism. These interactions are what we call: events.)

• The above statement is a direct challenge to the program of classical physics which, historically, has always been a reductionist one. That is, the program’s goal was to explain gross, macroscopic phenomena in terms of the motions of atoms, and these motions in turn in terms of the behavior of so-called subatomic particles--microscopic entities--all of them obeying the same classical laws. The ultimate classical goal was to explain phenomena--including gravitation and electromagnetism, in the seventeenth century framework of “atoms of matter in motion”. But if the Copenhagen Interpretation is correct, one cannot explain the behavior of the particles without reference to the apparatus used to observe them—an apparatus that must necessarily be a macroscopic one, so that humans can interact with them. Observation equals interaction; therefore it is only interactions may be said to happen. Therefore, in a sense, we have now come full-circle. We must become resigned to our inability to explain macroscopic phenomena in terms of the classical behavior of microscopic things, because we can only observe microscopic things by employing macroscopic apparatus. This is why Werner Heisenberg said: "We cannot know Nature itself, but only Nature as exposed to our method of questioning." The very word “particle” is a metaphor, a metaphor for a thing that is in one place and not in some other place. It is an unwarranted extension of our primitive vocabulary, into a region unsuited to us by our evolutionary heritage.

• Thus we find that the “registration” of a phenomenon is necessarily an irreversible interaction between a quantum entity and a gross, macroscopic observer of some type--perhaps the Universe itself. If we think about it, we will see that is impossible to see anything without the interchange of at least one quantum of light. This is indeed a strange state of affairs. But don’t worry: it gets even stranger!

The Collapse Of The Wave Packet And The Demise Of The Classical Trajectory When we look at the classical physics of Galileo and Newton, we see that one of the most central concepts is that of the trajectory. By way of review, a classical particle passes from one point to another. At any point there is
associated an instantaneous velocity, carrying that particle smoothly, on its way to the next point. From what we have learned about the Quantum Theory, this picture is an incorrect one. Let us see why this is so. Once we have made a measurement of the particle's position, all information concerning its momentum, (and therefore its velocity, since \( p = mv \)), has disappeared. Therefore we cannot say that the particle can be "carried smoothly to the next point." We have swapped smoothness and continuity for the behavior of a motion picture projector. In the absence of the particle's having both position and momentum, we cannot even speak of a trajectory. Instead we find ourselves looking at a set of isolated points, where we have made isolated position measurements. Adieu, M. Laplace!

Enter John von Neumann with a question: What is meant by an Observation? A Variation On The Copenhagen Theme.  

John von Neumann was a mathematician, and one the brightest men of his time\(^8\). During the 1930’s he applied his formidable talents in an attempt to solidify the logical foundations of quantum mechanics; the result of his efforts was the monumental\(^9\): *die Mathematische Grundlagen der Quantenmechanik*, published in 1935. This awesome treatise, bristling with intimidating arrays of abstract notation, functioned as a kind of “Quantum Bible”—referred to, but seldom read. It wasn’t even translated into English for another twenty years. It just made physicists more comfortable, knowing it was there. One of the most difficult problems von Neumann grappled with in his “bible” was the problem of Observation and the Observer\(^10\). What he had to say on the subject was, well, strange.

In the first place, von Neumann said, the observing apparatus is really made out of atoms; therefore it, too, is a collection of quantum entities, and must itself be of a quantum nature, representable by an appropriate Schroedinger wave. Remember, if we consider the Two-Slit experiment, we cannot say whether the electron went through one slit or the other, unless we first make an explicit measurement by means of a detector. In the absence of a detector, the electron is therefore in a state of "going through both slits." Such a schizophrenic arrangement is a kind of trademark of quantum behavior. It is called “a coherent superposition of states”—partially “upper-slit”, partially “lower-slit”\(^11\); and it is just this superposition of states that causes the phenomenon of interference. Suppose, then, we were to put an electron counter just to the right of one of the slits. As we have already seen, the interference pattern will disappear. Now here is the question: “Since the electron didn’t know it was going to be caught by a detector, then it was in a superposition of states until it landed in the detector. But, according to von Neumann, the detector is also of a quantum nature. Therefore it, the detector, is now in a superposition of states--partially in the state of having detected the electron, and partially in the state of not having detected the electron. However, suppose that the detector reading is noticed by the scientist in the laboratory. Does this mean that the scientist now in a superposition of states? Von Neumann said: No. Whenever we look, we notice with some relief that the world seems always to be, (quantum-theoretically speaking), in some well-defined state. From this observation, von Neumann was driven to the conclusion that it must be "human consciousness"\(^13\) that collapses the wave packet, drawing the fish of actuality, as it were, out of the sea of “potentia.”\(^14\) The idea we are discussing here is one that is of paramount importance, and the maxim of Wheeler bears repeating. We have already seen that, according to the Copenhagen Interpretation:

No elementary quantum phenomenon is a phenomenon until it is a registered phenomenon.

According to von Neumann then, human “consciousness” plays a role in creating reality, by registering
the phenomenon. According to him, it is human consciousness that collapses the wave packet. This, of course, places the universe in a very strange position. In this view, the Universe exists only because of us humans! (Such a responsibility!) Some of it has already been observed by human beings, and has promoted it to a state of actuality. Presumably, the rest of the universe remains in a kind of limbo: a perpetual superposition of quantum states, without “reality.” It should not be surprising if von Neumann's idea caused a great degree of skepticism in some circles. Read on; for there is more.

The Famous Case Of Schroedinger’s Cat.

Von Neumann’s solution to the Measurement Problem, (the problem of the Observer), produced hoots of amusement and howls of outrage among most of his colleagues. As a result, Erwin Schroedinger was inspired to produce the following memorable Gedankenexperiment (thought-experiment). Consider a cat, which has been placed in a sealed box. This box contains the following diabolical device: a feebly radioactive lump of material, positioned so that it is adjacent to a radiation detector. Whenever one of the radioactive atoms decays, it emits an electron, which then enters the detector. The pulse produced in the detector by the electron can be suitably amplified until it produces a macroscopically effective voltage surge. (There is no problem here; that is how a Geiger Counter works). This voltage can be made to operate a mechanical device, which in turn causes an ampoule of cyanide to drop into a vat of acid, producing a lethal dose of hydrocyanic acid gas. If this happens, the cat will surely die. A microscopic quantum event has thus managed to produce a very macroscopic death. Now let’s review the above scenario from the viewpoint of the Quantum Theory. The decay of the radioactive nucleus is purely a quantum-mechanical affair. A Schroedinger wave function can be easily written down to describe the probability of its happening. Therefore, as long as the box is sealed, we will have no way of knowing whether the decay has occurred or not; the nucleus is in a coherent superposition of states: undecayed + decayed. When the nucleus decays, the superposition has “spread” to the System: [nucleus + detector]. From there the superposition rapidly infects the rest of the System: [nucleus + detector + cat]. Thus the cat is in a state of superposition: both “alive” and “dead”. In the end the superposition is finally lifted when someone dons a gas mask and opens the box. In the mind of Schroedinger, (and of millions of others), this was (and is) a ludicrous situation. But ponder it as we might, there seems to be no way out. That is, there is no solution that will preserve the language of the Quantum Theory on the one hand, and that of everyday macroscopic usage on the other. It goes almost without saying, that in our ordinary, non-quantum lives, cats are either alive or dead; they are not found in a superposition of states. But then, how shall we describe the situation in a matter compatible with the Quantum Theory?

The Curious Episode Of Wigner’s Friend.

A further twist of the tail of Schroedinger’s Cat is this: the box with the cat inside is located in the study of Professor Eugene P. Wigner, a friend of von Neumann's. A laboratory assistant opens the box and looks in. Ah! The wave function has now been collapsed by the “human consciousness” of the assistant. But how about Professor Wigner? He doesn’t know yet about the cat. So is he in a superposition of states: “happy” and “sad”? And when he finds out, (assuming that his assistant has survived any residual dose of cyanide), and goes home to tell the news to Mrs. Wigner, is she waiting for him in a superposition of states? Does ordinary awareness mean one thing, and Consciousness mean something quite different? Clearly some vital ingredient is missing from our understanding. But philosophically minded scientists have been arguing about this ever since. Some scientists maintain that once quantum
transitions become amplified to macroscopic size, they become irreversible, and all coherence is lost. The latter theory appears to explain the collapse of the wave packet, and thus seems to be the most fruitful approach—the idea of “quantum decoherence.” What is meant by quantum decoherence? So far we have learned that quantum systems can exist in coherent superpositions of states. But when such systems come into contact with one another, the superpositions quickly become blurred, producing, in the limit, effects that cannot be distinguishable from classical phenomena. This effect has indeed been observed and measured, and the observations seem to agree with the theory. But in another sense, quantum decoherence merely begs the question. Amplification of a quantum event to macroscopic size is merely another way of saying that the Universe has observed that event. Further, has the superposition of states been really destroyed upon measurement? Or has it merely become more complex, by incorporating the atoms of the detectors? And there is an important catch here: under some conditions it is possible to recover the initial superposition, even after it has been lost: (the so-called ”quantum eraser” experiments). We shall return to this topic later. So the Observer problem does not go away so easily. The most attractive feature about the universe is that it seems beyond our ability to understand. Otherwise it would simply be boring.

**Another Example Of The Problem Of Observation.**

We have arrived at a pivotal idea in the Quantum Theory, and therefore it is worthwhile for us to look at yet another example, a very simple one. This time, think of a photon as a “system”, passing through a glass window. It has, say, a 96% chance of getting through the glass, and thus it will be reflected back from the window 4% of the time. Now let's place a piece of photographic film in such a way as to intercept all of the reflected photons. By the rules of Quantum Theory the photon, until its capture upon the film, is in a coherent superposition of states, i.e., [reflected + transmitted]. But when the film has “observed” the photon, at this point, as far as the photon is concerned, the superposition has broken down. Now, instead, think of the expanded “system”, consisting of [photon + film]. The film, made of silver bromide molecules, is also of a quantum nature. Therefore it, together with the photon, must also be in a superposition of states, one with a photon capture, and one without a capture. The system of [photon + film] cannot, unaided, resolve the superposition. It cannot tell us which state it is in. It needs help. This question is answerable only by the intervention of some entity looking in from outside the system: an Observer. Let us say that a human looks at the film. What happens then? The human, being on the outside of the [photon + film] system, can now collapse the wave packet of the system [photon + film], and discern whether the photon has entered the camera. But then, what of the new system, [photon + film + human]? According to von Neumann, the human observer can be thought of as being different-in-kind from the film, in that the human is self-aware, and knows when he/she has seen the spot on the film; by itself, the film can't do that. Consequently, for von Neumann, it is “human consciousness” that collapses the wave packet. At this point I must, as author, break in to say that I do not share von Neumann's enthusiasm for the singular power of "human consciousness," but there is a very important theme here; namely: there are Systems and there are Observers. To collapse the wave packet, the Observer cannot be part of the system. For the System cannot collapse its own wave packet. The Observer must then be in some sense, external to the System. But, taken to its logical conclusion, the System is the Universe. Then we must ask: What is meant by the phrase: “outside the Universe”? What is the Observer? We need to return to this question!
The Universe As Observer

There seems to be one solution that Saves The Appearances. We have seen that a System can never collapse its own wave packet. Since the system is ultimately the Universe (whatever that might mean), we can either regard the Observer as either “outside” the Universe, or regard the Universe itself as the Observer, in von Neumann’s sense of the word—in the sense that the Universe is in some way, Conscious—in the same reflexive, self-aware way that “human consciousness” seems to function. This word: “Consciousness” is normally used in the English language to express a condition synonymous with our awareness as individuals. But when we use it in that manner we are getting into deep metaphorical water, (so to speak), for the word "consciousness" is one of a relatively recent provenance. It doesn’t even exist in the French language, separately from the word “conscience”--the French would be forced to use some circumlocution such as: l'état d'esprit. We will have more to say about Consciousness in a later chapter. (See Endnote 13, for more on this subject). Erwin Schroedinger, who read widely in the schools of Indian philosophy, had the following thing to say about the matter:

Consciousness is a singular for which there is no plural.

At this point we would do well to observe a certain parallel that seems to exist: that of Consciousness and Life. Both of these words lead a double "life," as it were. When we talk about Life, for instance, we can talk about a process, inconceivably grand in scope, spanning the past 3 or 4 billion years on this planet, and quite possibly extending throughout the entire Universe. Or we can shrink the concept down to the measly share which we, as individuals, happen to hold in this cosmic project. The latter alternative creates such problematic phrases as "my life," "his/her life was saved," or "many lives were lost." These last are clearly incompatible with the larger picture, and some of them are internally inconsistent. The same situation seems to hold with respect to Consciousness. Does Consciousness transcend the human skin, thereby acquiring a "capital C"? This last idea is, of course, rankest heresy in materialist circles; but we shall see that considerable empirical evidence does exist, suggesting that the human skin is considerably more permeable than mere theory would allow. Perhaps Consciousness transcends us, just as Life does.

From the foregoing it appears that our attempts to interpret the Quantum Theory have made us see that we are Strangers in a Strange Land—a landscape far off the beaten track of Western Philosophy. It is for this reason that pioneer quantum physicists such as Bohr, Schroedinger and Heisenberg looked to the philosophies of Asia for help. It is beginning to appear as if the categories that had previously come to be self-evident over the course of Western history have been sent to the well, and have returned with empty buckets. Philosopher Sidney Hook once remarked that:

We know that when Aristotle drew up his table of categories, which to him represented the grammar of existence, he was really projecting the grammar of Greek language on the cosmos.

My own feeling is that this kind of projection is what we human beings do continually. We have been projecting our own language onto the Cosmos from the very beginning, simply because we are so constructed that we can do no other. We have evolved into a niche in that same Cosmos, and thus there will inevitably be instances, such as the macroscopic world, when our language will agree dramatically with our experience. But there will always be those other times, when our language will fail; for language itself apparently uses the same neural pathways as does our animal sensory-motor system.
The Wave Of The Future.17

If you were to consult any textbook on quantum mechanics, you would find that the Schroedinger wave function has an equal “twin”—a conjugate function by which it must be multiplied in order to become properly “squared,” where this “square” gives the probability of finding the “particle” in a given state. This “Schroedinger twin”, generally disregarded as merely a part of the mathematical formalism, propagates “backward in time” from the future—until just that moment when it meets its opposite number moving “forward in time”, out of the past. At that instant the wave packet is said to be “collapsed” by the act of observation. In the next chapter we shall also see that quantum events have also been found to be definitely non-local in space. Assuming that this is correct, (since Einstein has shown in his Special Theory Of Relativity that space and time are indissolubly linked), it may just be possible that the Schroedinger “twin” is telling us how it can be that the future helps, in some strange way, to create the present, as well as the past! More evidence supporting this idea is supplied in the very next section.

The Delayed Choice Experiment.

One day, while pondering the meaning of the Double-Slit Experiment, John Wheeler devised the following ingenious “thought-experiment”: we start out with the standard Double-Slit Experiment. First there is a photon source; next the photon beam passes through a narrow slit in a plate; from there it travels to a second plate, one having two parallel slits. On the other side of the second plate, and at a considerable distance from it, the beam encounters a screen. So far, everything is exactly as it was before. Left undisturbed, the beam will produce interference fringes upon the screen. But this time we have a trick up our sleeve; for now the screen has become a Venetian blind! Behind the Venetian blind lurk two photon detectors, each of them aligned with one (or the other) of the two slits. We also refine our apparatus so that it produces just one photon of light at a time. We can easily calculate how much time it takes for the light wave to pass through the slits; therefore we can wait until after the wave has already committed itself to a course of action, before trapping it. It is only after the light wave has gone through the slits that we make the decision to open or close the blind! See figure 11-1. The prediction of the Quantum Theory is this: if we close the blind we get the interference pattern; if we open the blind we will get a click from one or the other of the two photon detectors, but not from both of them. Thus in a sense, our manipulation of the Venetian blind determines how many slits the particle will have already passed through. There is, of course another, possibly equivalent way of expressing this result. It is possible to say that the photon didn’t actually have a path—it was in a superposition of states until we gave it a path by making a measurement with the photon counter. But in either case, our measurement made in the present has, in a sense, served to write the history of the past.
A Cosmic Delayed Choice.
To make his point more forcefully, Wheeler produced an even more bizarre thought-experiment. At the other side of the Universe, several billion light-years away, there is a quasar. As the light from the quasar travels earthward, it has to pass around a massive galaxy, whose gravitational field bends the light from the quasar, acting as a "gravitational lens." See figure 11-2. The result of this gravitational lensing is that: a double image of the quasar is formed by our earth-bound telescopes. If a Venetian-blind screen were set up on a satellite, located at the point where the two beams cross, (position A), an interference pattern would be formed, made up of photons, arriving coherently, but one at a time. If, instead, a pair of photon detectors were set up at the focal plane of the earth-bound telescope, (position B), then the separate images of the quasar would be resolved as two separate streams of photons. Furthermore, whenever one apparatus clicked to signal the arrival of a photon, the other would be silent.

The crux of the argument here is that the distance from the earth to the crossing point of the two beams is only a small fraction of the distance from the earth to the giant galaxy-lens. So that the decision to make one measurement or the other can be made long after the beam has passed around the distant galaxy—after it has already "committed itself" to one path or the other—or to both. Thus in a sense our measurement is creating the history of an event that "took place" long before there was any life on earth. Bizarre? Yes indeed.

After reading this account, the reader has every right to ask the question: "This is well and good as a "thought-experiment", but what happens when you do a real experiment? You will be happy to discover
that the Delayed Choice Experiment has actually been performed in the laboratory, by two separate teams of researchers; and that the results are exactly as Wheeler predicted. Below is a description of the experimental set-up. See figure 11-3.

Our first task is to obtain a stream of photons that will arrive at some pre-arranged destination, one at a time. If we are successful, our beam will pass the beam-splitter test. One creates a beam-splitter by silvering the surface of a piece of glass—essentially a very special "one-way mirror". This silvering job is done very carefully, in order to ensure that exactly half of the intensity of the light reaching the mirror is reflected, and half transmitted. In this way we have created a device that will "split" the beam into two equal parts. By the use of ordinary mirrors we can re-direct the two parts of the beam into separate photon counters. We will know that we are getting one photon at a time through the system whenever the counters click separately. Now we are ready to hold our breath and perform the experiment. At the
beginning, the photon arrives at the first beam splitter, BS1. There are two possible paths for it to take; let’s call them X and Y. Each path has a mirror, M, which reflects the beam to the Crossing Point—where the two beams intersect. If both paths are of equal length, and a second beam splitter BS2 is now inserted at the Crossing Point, an interference pattern will be visible upon the beam splitter. If the second beam splitter is now removed, the two beams will be allowed to go on to the end of their joint life—to be registered at one or the other photon detector—but never at both. As a result of a lot of hard work in the laboratory, it has become technically possible for us (a) to produce just one photon at a time, and (b) to know when that photon has passed the first beam splitter. Beyond that point, since a photon is normally supposed to be indivisible, it must be found either in path X or path Y. Yet, when the second beam splitter is inserted, an interference pattern, the tell-tale sign of coherent superposition always appears. When the second beam splitter is removed, the photons register on one detector or the other, but not on both at the same time. Now here is the crucial point: the decision whether or not to insert the second beam-splitter can be postponed until after the photon “passes” the first beam-splitter. In this way we have designed an experiment that has permitted us to Delay The Choice. In the words used by John Wheeler, (note carefully: this remark is in the context of the two-slit thought-experiment, not the real experiment, the one performed in the laboratory. The student must be able to tell the difference): “We do not have to decide in advance which feature of the photon to record, whether ‘through both slits’ that pierce the metal screen, or ‘through which slit’. Let us wait until the quantum has already gone through the screen before we—at our free choice—decide whether it shall have gone ‘through’ both slits or ‘through just one’." In this way we appear to “cause” an event that has “happened” in the past. But the Quantum Theory says that the event has not “happened” until we have observed it.

**Yet More Quantum Weirdness.**

It is easy to fall into the error of assuming that interference is a phenomenon that occurs when two photons interfere with one another. Actually, photons interact only very, very weakly with each other. Interference is always produced when a photon interferes with itself! The interference patterns formed in say, the Two Slit Experiment, are made by single photons whose arrivals at the detectors are deliberately spread over a substantial interval of time, just in order to eliminate this possibility.

In the year 1967 a truly bizarre result was observed by R.L. Pfleegor and L. Mandel, two physicists at the University of Rochester. They used two lasers whose beams, separated by a small angle, crossed at a screen. The lasers were arranged in such a manner as to operate independently. The photon beams were sufficiently weak that the researchers could confidently expect a decent interval to elapse between the arrivals of successive photons at the screen. To their surprise, they still obtained an interference pattern! It appeared as if one of the lasers, though not apparently the source of the photon arriving at the screen, actually cooperated in producing the interference of the photon that was apparently emitted from the other laser! Question: How can we think about such an outlandish thing? Answer: Think of the two lasers as slits in a double slit experiment! The photon is in a superposition of states; it doesn’t make sense to ask which laser it came from. How could it matter to the photon, when the final result is the same in either case?

**The World According To John Archibald Wheeler.**

To John Wheeler, there are two outstanding paradoxes, which in a sense converge to form the “ground rules” of how we might think about the Universe. They point the way past phenomenal reality,
suggesting the existence of an unknown Reality that lies well beyond our reckoning. The first of these is the fact of Black Holes. Einstein had predicted that clocks will slow down in a gravitational field; and this has been found to be a fact—the phenomenon was measured forty years ago, in the tower of the venerable Jefferson Laboratory at Harvard University. But in a gravitational field of the kind that must exist within the insatiable maw of a Black Hole, the rate at which a clock ticks must slow down to zero. Time must indeed "have a stop"; and all space is compressed to less than a dot—less than a pinpoint. Since the laws of physics address the evolution of systems in space with respect to time, it follows that the laws of physics themselves can no longer hold under such extreme conditions. So, physics must also "have a stop"! This idea has struck a devastating blow to a long tradition of science in which one was supposed to be given over to contemplating the "eternal, unchanging laws of Nature". This kind of a "demotion" is reminiscent of the Copernican Revolution, which rudely removed the earth from the center of the universe! Fascinating! In the future, are the laws of physics to be considered as mere “local ordinances”?  

The second paradox is of course the Quantum. Wheeler contrasts the Old Physics with the New. The Old Physics allowed us to view the Universe from “behind the safety of a one-foot-thick slab of plate glass,” as it were, (see figure 11-4) “without getting ourselves involved”. According to The New Physics, the truth is quite different. 

“...we have in effect to smash the glass so as to reach in and install measuring equipment. We can install a device that measures the position x of the electron, or one to measure its momentum p, but we cannot fit both registering devices into the same place at the same time. Moreover the act of measurement has an inescapable effect on the future of the electron. The observer finds himself willy-nilly a participator. In some strange sense this is a participatory universe.”23

Since, in the Delayed Choice Experiment we, by virtue of a decision which we make in the “here and now”, have an irreversible influence on what we can say about the “past,” then perhaps it is true that the past has no existence except as recorded in the present. How can you tell the “real” past from the measured past? You can’t! In Wheeler's words: "Registering equipment operating in the here and now has an undeniable part in bringing about that which appears to have happened."
Wheeler's Conjecture On Observer Participancy.

Consistent with the results of the Delayed Choice Experiment, we find that in addition to the creation of the present, the past of the Universe is also being brought into actuality as a result of billions upon billions of chance events, the results of observer participancy, combining to build the "reality" that we now experience. We have been conditioned to think of the Universe as having been created from nothingness. But the Greek philosopher Parmenides ruled out this notion by pointing out that: "what is not can not even be thought of". How does one go about thinking about Nothing? In this way Wheeler is driven to conclude that, since phenomena occur—for we do, after all, experience them, the Universe can be thought of as a kind of "self excited circuit,"--that the universe, with its laws, is a vast exercise in self-organization-- another way of saying that it is Participatory—self referential, as in Douglas
Hofstadter's book: "Goedel, Escher and Bach." It is beginning to look that way. Wheeler likes to see it in a way that is illustrated in figure 11-6.

Notes to Chapter Eleven:

1. There are elegant computer programs such as Mathematica, which permit a relatively ignorant operator to calculate the solutions to arcane problems in quantum mechanics, and display the result graphically upon the screen, even though there is no way to describe what is being operated upon.

2. Physicists trained in the period after World War II were, for the most part, "connecting the dots," left by giants such as Einstein, Bohr, Schroedinger and Heisenberg. The Frontier had been tamed; almost all of the newer physicists are merely "mopping up" after them. They wear ten-gallon hats, these cowboys, but they merely drove around in pick-up trucks. For the most part, they still do this. Once upon a time, Science was a vocation. Now, it's just a job.

3. There is an excellent review of the ways in which quantum physicists have tried to cope with The Mystery in a wonderful book by Nick Herbert: Quantum Reality, Doubleday Anchor Books, Garden City NY, 1987. Herbert presents the subject in a complete form; yet it is still accessible to the general reader.

4. An excellent source book is entitled The Ghost In The Atom, a compilation of interviews of physicists on The Third Programme, a famous "high-end" British radio show. The interviews, skilfully conducted by the physicist P.C.W. Davies, bring out clearly the dissatisfaction felt by some physicists with the Copenhagen Interpretation, as well as the pathetic ambition felt by these people to flesh out the Copenhagen Interpretation with some kind of ontological "picture"—some kind of visualizable "quantum world".

5. Wheeler, Head of the Institute For Advanced Study of the University of Texas at Austin, was for many years Professor of Physics at Princeton University. He worked with Bohr on the
development of the first atomic bomb, and was Richard Feynman’s thesis professor. He has
since died, but he lived into his nineties.

By “registered” Wheeler means “recorded”. The idea is that the result of the observation
must be amplified and irreversibly recorded by some laboratory apparatus of macroscopic
size. Wheeler does not believe that Consciousness, human or otherwise, is necessary to
register an event. But after some study, I am convinced that he equates Consciousness with
ordinary awareness.

This restriction is a direct result of our macroscopic size and the evolutionary origins of our
intelligences.

It was von Neumann who designed the present layout of the digital computer; your pocket
calculators and personal computers are constructed in accordance with his design. Born in
Budapest in 1903, he died in the U.S. of a brain tumor in 1957.

Translated into English this is: The Mathematical Foundations Of Quantum Mechanics,

Technically, this is referred to as “the Measurement Problem”.

According to all Copenhagen interpretations, it is not merely we who are ignorant of which
state the electron is in. The electron is ignorant, as is also Mother Nature. Up to this point,
von Neumann takes the same view of the matter as Bohr does. Where they differ, is that for
Bohr, the observing instrument must needs be classical. For von Neumann, the observing
instrument is a collection of microscopic objects, all of them obeying the laws of Quantum
Theory, and the wave packet is collapsed by human consciousness.

One state says “particle”; the other says “no particle”. Both states exist until one or the other
is recorded—in some way. Moreover, von Neumann traced this chain of superpositions—the
von Neumann chain—all the way into the visual cortex of the researcher.

I have placed these words in quotes, because we cannot understand the word:
“consciousness” in any analytical way. It is a kind of experience, not a concept. We know
what “awareness” is; we know what it means to be self-aware. But Schroedinger, who was a
Vedantist, could say that “consciousness” is One. Following Lakoff and Johnson, (p. 116), a
“dictionary definition” of the word “consciousness” would attempt to express the concept in
terms of things inherent in it. More useful would be the way in which humans understand the
word, and function in terms of it.

The word: potentia, used by Heisenberg, comes out of the vocabulary of Aristotelianism.
Heisenberg reasoned that the Schroedinger wave expresses a tendency for things to happen,
and that all things have the potency, the tendency to happen—until they actually happen.

In a recent experiment at the Bureau of Standards at Boulder CO, a single Beryllium ion was
placed in a coherent superposition, in which the two states were separated from each other by
a distance of 80 nanometers, (80 X 10-9 meters)—1500 X the size of a hydrogen atom. If the
distance were 12X larger, it would even be possible to see it with the human eye!

Humans apparently possess the property of self-awareness. Amit Goswami, in his book: The
Self-Aware Universe, Tarcher/Putnam, NY, 1993, has made a skillful attempt to deal with
this slippery question. He has taken the grand, classical Advaita Vedanta position: that
Consciousness is the Ground Of All Being. By Goswami’s hypothesis, Consciousness
collapses the wave function by becoming aware, and reflexively becomes aware by
collapsing the wave function. It is difficult to do justice to this kind of statement when
merely using one’s discursive faculties. But, when seen from a meditative state, it does seem
to have the “ring of truth” to it. It makes sense when the subject-object distinction
evaporates. Human “consciousness” seems like unto a set of parallel mirrors such as one sees
in barbershops. We know, we observe ourselves knowing, etc., etc., ad infinitem. The
Vedanta thesis of Goswami, is that there are not separate consciousnesses, there is just One—
and this is what collapses the wave packet. A fascinating idea.

(17) *The Transactional Interpretation Of Quantum Mechanics*, by John Cramer, Review Of

(18) This occurs because the Schroedinger wave function is a “complex number”, and must, to
yield a real probability, be multiplied by its “complex conjugate”.

(19) This is an experimental device called a “collimator”, placed there to guarantee that the beam
will be rectangular in cross-section.

(20) Having passed the first beam splitter is entirely equivalent to having passed through the two
slits in the double-slit experiment. Thus the delayed-choice experiment as performed in the
laboratory is entirely equivalent to the experiment with the Venetian blind, first conceived by
John Wheeler. This experiment has been successfully performed at Munich and in Rochester.
On both occasions the results supported the Copenhagen Interpretation of the Quantum
Theory.

(21) A study was done using electrons in the late 1940’s in the (then) Soviet Union, which was
reported in a paper entitled: *Diffraction Of Individually Proceeding Electrons*, in which tiny
interference effects were observed between two consecutive passages of an electron through
the device, being about 30,000 times longer than the time needed for a single electron to pass
through the system. For a more extensive reference, see *The Philosophy Of Quantum

(22) See the paper: *Interference of Independent Photon Beams*. Physical Review, 159, 1084-1088
(1967).

(23) See the fascinating essay: "Beyond The Black Hole" by John Archibald Wheeler, in *Some
CHAPTER TWELVE
THE NON-LOCAL UNIVERSE

One can escape from this conclusion only by either assuming of B that it (telepathically) changes the real situation at G, or by denying independent real situations as such to things which are spatially separated from each other. Both alternatives appear to me entirely unacceptable.

Einstein

Nothing in the universe is contingent, but all things are conditioned to exist and operate in a particular manner by the necessity of divine nature.

Spinoza, Ethics, Proposition XXIX

The Einstein-Podolsky-Rosen Paradox: The Search For An “Element Of Reality”. 

After the Nazis had come to power in Germany, Albert Einstein and his wife found refuge in the United States. By the year 1935, in his new intellectual home at The Institute For Advanced Study, working with the aid of Boris Podolsky and Nathan Rosen, he was able to renew his long, paradoxical intellectual duel with his friend and nemesis, Niels Bohr. This, Einstein’s final thrust in that historic skirmish, appeared in the form of a paper entitled: Can The Quantum-Mechanical Description Of Reality Be Considered Complete? Published in the Journal: The Physical Review, it has since become famous as the Einstein-Podolsky-Rosen Paradox, or the EPR Paradox.

The EPR argument (a Thought-Experiment) is an ingeniously simple one. We start out with a particle that is at rest with respect to our laboratory. Therefore its momentum is equal to zero. The particle suddenly decays into two identical sub-particles, which still have to conserve momentum; so they move off in opposite directions, as shown in figure 12-1.

![Figure 12-1](image)

According to the rules of the Quantum Theory, a particle cannot simultaneously possess a position and momentum. But we can measure, say, the momentum of one of the two particles. Since the total momentum of the system is still zero, the momentum of the second particle must therefore be the negative of the momentum of the first particle. Therefore, we have ascertained the momentum of the second particle without measuring it directly. By the rules of Quantum Theory, the news of the result of the measurement on the first particle would have to travel to the second one instantaneously, thus violating Special Relativity. But Special Relativity has never been found to be wrong. Therefore,
Einstein and his colleagues reasoned, whatever might be the value of the momentum of the second particle, it must nonetheless have had a well-defined momentum from the start; a result which is contrary to the Copenhagen Interpretation. The three collaborators expressed their assertion in the following curious fashion:

“If, without in any way disturbing a system, we can predict with certainty the value of a physical quantity, then there exists an element of physical reality corresponding to this physical quantity”.

This was the main thrust of the argument: it was a statement of the philosophy of Realism, of Objectivism. Einstein believed that when we measure something, we are measuring a real physical quantity—something that is already “there”. Further, since, according to EPR, the momentum of the second particle is “an element of physical reality” not available from the Quantum Theory, EPR claimed that their result was sufficient to show that the Quantum Theory is an incomplete description of reality.

Bohr’s Response was elegant, (although he had agonized over it for some time). It involved showing that the EPR Thought-Experiment is a general case of the kind of double-slit experiment that he and Einstein had been discussing all along, and that measurements of position and those of momentum were fundamentally incompatible with each other. But Einstein and Company were not to be so easily put off. They had seized upon one of the essential peculiarities of the Quantum Theory, and they did not intend to let it go. For the question still remained; what would happen if you really performed that experiment? It soon became clear, however, that this version of the experiment could never be performed; for like most Thought-Experiments, it is impractical at the performance level.

The years passed, bringing in their wake the anguish of World War II, the development of nuclear bombs, and in the U.S., the Hobbesian “national security state”. In the general commotion the EPR paradox was almost forgotten. After the War came the demagogic witch hunts for communists (mostly imaginary ones—they hide under the bed), and notably a collision which occurred between two polar opposites: The House Un-American Activities Committee on the one hand, and a truly honest man named David Bohm on the other. Bohm had refused to testify against his colleagues—an act that caused him to forfeit his position on the faculty of Princeton University, and ultimately even his American Citizenship. Subsequently, he led a kind of gypsy existence, teaching in Brazil and in Israel, before finally accepting a professorship at the University of London. But it was Bohm who, before his exodus from the U.S., had suggested a crucial revision to the EPR experiment. It was this suggestion, which opened the door for the historic performance in real laboratories of a real experiment, as opposed to one that was merely of the "thought" kind.

Instead of trying to measure positions and momenta of particles that we can’t even see, Bohm argued, what we really need to do is to measure their “spin-angular momenta”, (called “spins” for short). Spins are very severely quantized, and can be measured with a high degree of reliability. But during the fifteen years which had intervened between the appearance of the EPR paper and Bohm’s variation, physicists had been preoccupied with learning how to apply their new quantum toy to everything in nature; they didn’t really care how it worked. So no one wanted to spare the time to learn how to apply Bohm’s idea in a real laboratory setting. Philosophical questions, such as whether or not positions and momenta really exist when no one is looking at them—these were always the badly “underfunded” step-children of science. It must be admitted that physicists are, on the average, a surprisingly unreflective lot; and the
physics community was much more absorbed with the applications of the Quantum Theory, than with its implications for the Universe. (This, unfortunately, is still the case.)

But John Stuart Bell was an exception to the rule; a “particle physicist” then working at CERN (Centre Europeen pour la Recherche Nucléaire) in Geneva, Bell had been fascinated ever since his student years by the arcane field of Quantum Reality. So in 1964 he took a sabbatical leave, and decided to try his luck with the EPR problem. In his heart he hoped that Einstein was right, and that the Quantum Theory was wrong, (which had become Bohm’s position also). And in a moment of brilliant inspiration, Bell produced a mathematical theorem in the form of an “inequality”-- one that would provide the necessary laboratory test of EPR. An analysis of Bell’s theorem indicated that there are three pre-conditions, which must be satisfied for the Inequality to hold.

• First, there is the principle of Einstein Locality. This principle says that two observers cannot communicate with each other using signals that travel faster than light; (sounds safe enough, doesn't it?)
• Second, there is the doctrine of Realism, or Objectivism, which holds that observed phenomena are caused by some physical reality whose existence is independent of human observers. This was, of course, an Article Of Faith.
• The third is that inductive inference is a valid mode of reasoning—that legitimate conclusions can be consistently drawn from systematic observations. No Voodoo: This idea is "Square One" for Science. In short, if the Bell Inequality holds, then Einstein was right, and the world operates according to the tenets of “Local Realism”. But otherwise, at least one of these assumptions must be wrong.

Eight more years dragged by before anyone mustered the interest (and the requisite funding) to test the outcome of Bell’s Inequality. But then, in the period between 1972 and 1976, no fewer than seven experiments were performed, mostly with photons. Two of them supported Bell’s Inequality, but no fewer than five of them showed that the Inequality was violated—even not really decisively. The “error flags” on the data were a bit too large, as was also the time lapse between the arrival of correlated photons. In plain language, there were just too many loopholes.

However, the best experimental effort was yet to come; this was made between 1979 and 1982 by a team of graduate students at the University of Paris. This team consisted of Alain Aspect (its leader), Jean Dalibard, Philippe Grangier and Gérard Roger—a kind of orphan effort, using laser equipment borrowed from other labs. But their results demonstrated that Bell’s Inequality was violated—and this time decisively. This experiment is very easy to understand; but first one must learn some basic facts about polarized light. In the next section you will be able to get acquainted with this disarmingly simple, but fascinating quantum phenomenon.

**How Polarization Works, or rather, What Polarization Does.**

To understand the polarization of light, we need to understand that light is transmitted as a wave. Moreover, light waves have something in common with water waves, and also with waves traveling along a string; namely, the amplitude of the vibrating electric field of the light wave is always in a plane at right-angles to the direction of the wave's progress. The plane in which the vibration lies is called the plane of polarization of the wave.

**Now for something truly mysterious!** It is only natural for us to assume that the polarization of a given
light wave always has an intrinsic direction: i.e., that the wave "comes from the factory polarized." **But, according to the Quantum Theory, this is not the case.** Whenever we wish to perform an experiment to measure the direction of polarization, we always have to force light into some kind of interaction with matter. As we have seen earlier, matter interacts with light in its particulate form—the photon. It is this interaction that gives the photon a definite polarization. To understand what happens, let's look at the interaction that takes place when light strikes polaroid sunglasses. The all-important thing to realize about polaroid sunglasses is that light passing through them becomes polarized vertically. That is, the lens of the glasses contains thousands of tiny, thread-like crystals of a quinine compound, oriented vertically in the glass or plastic. Ideally, light must become polarized along the direction of those quinine threads in order to pass through the lenses. Any device that works like this is called a polarizer. Hence a polaroid lens acts as a kind of polarizer.

To understand how the Quantum Theory describes this interaction, let's see what the Theory says about what the polarizer does to an unpolarized photon. According to the Theory, the polarizer acts like a gatekeeper; in one case it will pronounce that the photon's polarization is parallel to the lens's axis of polarization, thus permitting the photon to pass through. Otherwise it will pronounce that the photon's polarization is perpendicular to that axis, in which case its passage will be blocked. Since our Polaroid Gatekeeper is unbiased and fair-minded, the probability of each occurrence is simply 50%. See figure 12-2.

Once upon a time a famous major league umpire was interviewed on a radio program. When the sportscaster conducting the interview asked the man how he called balls and strikes, the umpire replied: "Some of 'em is balls, and some of 'em is strikes; and some of 'em ain't balls nor strikes until I call 'em." According to the Copenhagen interpretation, polarizations, like all quantized quantities, are members of the umpire's third category. The "call" occurs when the photon interacts with matter.
And Now For The Next Round Of Polarization Tricks!

If we sever the two lenses of a pair of sunglasses, and rotate them at ninety degrees to each other, we obtain a near-total⁹ extinction of the transmitted beam. This occurs because the initially un-polarized photons have acquired a definite direction of polarization after passing through the first polarizing lens. After this, the probability of their being polarized at 90 degrees to that direction is exactly zero. Now, if we want to see what happens if we start out with the polarization axes of the two lenses aligned parallel to each other, and then rotate one of the lenses slowly, we find that the transmitted beam becomes gradually fainter, slowly at first, and then faster, until the final extinction occurs when the two lenses are oriented at ninety degrees¹⁰ to each other, in agreement with the previous sentence.

In particular, if the two lenses are oriented at thirty degrees to each other, 75% of the incident photons pass through; and, if the lenses are oriented at forty-five degrees to each other, 50% of the incident photons pass through; and finally, if the lenses are oriented at sixty degrees to each other, 25% of the incident photons pass through.

Remember! It will be necessary and sufficient for you to remember these last three facts, in order for you to follow the main arguments of this chapter, and thus for you to understand the Aspect Experiment. And so I leave this detail up to you. (See Appendix E for a more extensive explanation of polarization and the Aspect Experiment).

Essential Details Of The Aspect Experiment.
Physicist Nick Herbert¹¹ has provided us with a wonderful, simplified version of the Aspect experiment—that allows us to grasp the essentials, while at the same time sparing us the string of necessary experimental refinements with which it was actually adorned. An essential feature of our experiment is a “photon source”, in which Calcium atoms are excited by laser bombardment. The Calcium atoms then decay from their excited state, giving off what is called a “cascade” of two¹² correlated photons, one green and one blue¹³ which fly off in opposite directions, to the right and left, as seen in figure 12-3.

![Figure 12-3](image)

The source of the calcium atoms here is referred to merely as 'source'.

If we hold a polarizer in each beam of photons, we will find that their polarization has no preferred orientation; that is, all directions of polarization will occur with equal probability. We know this, for the transmitted intensity of the beam always drops by 50% after we insert a polarizer. However, one result will be observed to occur invariably: if we hold the polarizers with their axes parallel, whenever a green photon passes through the right-hand polarizer, a blue one will always pass through the polarizer on the left. If the green photon is stopped on the right, the blue one will always be stopped on the left. The correlation here will be 100%. But if we look, say, at the results of emitting 100 green and blue photons while holding the polarizers at some arbitrary angle to each other, there will be a partial mismatch
between the results obtained at the two sides of the laboratory. Sometimes a green photon would pass through, but the blue photon wouldn't, and vice-versa. **We shall soon see that this effect is all-important.**

For simplicity, let’s adopt a “convention”, a kind of metaphor. We shall refer all of the orientations of the polarizers in this section to the face of an imaginary clock. Thus, one particular orientation (the vertical), of the polarizers will be called the “12 o’clock position”. The reason that this convention is so useful is that the angle between 12 o’clock and one o’clock is thirty degrees—a very useful fact. Employing this terminology to review the argument so far: we find that when the two polaroids both point to 12 o’clock, the data for the green photons match those for the blue photons—exactly.

At that point came John Bell’s flash of inspiration, a simplified version of which is this: Let’s rotate the right-hand polarizer through thirty degrees to the one o’clock position. From the facts I told you to remember, the proportion of passed photons should be reduced to 75% of those which would have passed if we had simply left the polarizer at the 12 o’clock position, as can be seen in figure 12-4.

![Figure 12-4](image.png)

Since the left-hand polarizer remains pointing to 12 o’clock, there will now be a mismatch between the data from the right- and left-hand polarizers—a mismatch of just 25%, corresponding to the 30-degree mismatch in angles. Now what would happen if, instead, we kept the right-hand polarizer in the 12 o’clock position, and tilted the left-hand polarizer through 30 degrees in the opposite direction—to eleven o’clock? The answer is that we would get the same result—a 25% mismatch. So far so good! But finally, voilà! la pièce de résistance! We tilt the right-hand polarizer to one o’clock, and also tilt the left-hand polarizer to eleven o’clock. The crucial question is: **what happens now?**

At this point we need to make a careful review of our assumptions. If we assume, along with Einstein, that the photons reaching our polarizers had an intrinsic polarization—"an element of reality", and were already polarized in the 12 o’clock direction, then the 12 o’clock direction for the photons is already determined at the source, where the calcium atoms are located. In that case, by tilting the right-hand polarizer, we are simply mis-matching 25% of the arriving photons. If we then tilt the left-hand polarizer through the same angle, but in the opposite direction, we are obtaining at most another 25% mismatch, for a total of a 50% mismatch, (25% + 25% = 50%). But at this point we must inject a small qualification into our argument. There will be certain instances where a mismatch on the left side of the apparatus will coincide with a cancelling mismatch on the right side, producing a net match. Therefore the total mismatch for all the photons will almost always be less than 50%. *If the polarization of the photons is indeed a property that they already have, prior to, and independently of any measurement, then according to EPR, the polarizations have already a built-in, “element of reality”. So, if the mismatch between the right and the left sides is ≤ 50%, the universe must be Real and Objective, and Einstein will have triumphed.*
But wait a minute! Suppose that we assume instead that the Quantum Theory is correct, and that the System actually consists of both photons at once, no matter how far they are separated in space, and not just either of them taken singly. In this case, if the right-hand polarizer points at one o’clock, and the left-hand polarizer points at eleven o’clock, the angle between those two polarizers will be now a full sixty degrees. (According to the important facts that previously I required you to learn), the mismatch corresponding to an angle of sixty degrees must be no less than 75%. But the Bell Inequality, predicting a maximum of 50% for the mis-match, must then be violated. Note that what we are saying is that in this instance, in accordance with the Quantum Theory, the photon initially had no fixed polarization at all, until we measured its value in the interaction with one of the polarizers. This last idea is, of course, one that is consistent with the Copenhagen Interpretation. See figure 12-5.

Figure 12-5

In the earlier EPR experiments there had always been a large, gaping loophole. Theoretically, information could have been able to travel across the laboratory at the speed of light, informing say, the left-hand polarizer of the settings at the right-hand polarizer before the photons could arrive. One of Aspect’s triumphs was to insert a set of optical switches in the paths of the photon beams, diverting them in such a way as to make the settings of the polarizers unknown to each other until it was too late for the information to travel from one polarizer to the other. Thus, although the polarizers were located a scant thirty feet from each other in the laboratory, they might as well have been stationed at opposite sides of the Universe.

The result of the experiment? The result was contrary to the predictions of EPR, the verdict was against determinism, against locality, and against the existence of previously existing "elements of reality"—and this time by 13 standard deviations! Bell’s Inequality had been decisively violated, and the Quantum Theory had come through with flying colors.

And What If We Had Tilted The Polarizers At An Angle Of Forty-Five Degrees?

The following is a suggestion proposed by my colleague, Professor Brusca. Suppose we tilted the right-hand polarizer at 45 degrees to the vertical. This would correspond to a time of 1:30 on our clock. Then the mismatch of the green photons, observed relative to the 12 o’clock position would be, as we have seen earlier, one of 50%. Suppose then, that we also rotated the left-hand polarizer 45 degrees in the opposite direction (to 10:30 o’clock). Then the blue photons would also be mismatched by 50%. But if Einstein had been correct, the mismatch taking place at the right side would be completely independent of the degree of mismatch taking place at the left, so that half of the mismatches would cancel out,
producing a net 50% match! However, the two polarizers are now at 90 degrees to each other. According to the Quantum Theory this configuration should produce a mismatch of 100%—a dramatic difference. There are probably reasons why this form of the experiment has never been done in a laboratory, but the point is certainly a valid one.

The Implications Of The Aspect Experiment? Perpetual Entanglement!

• The most important implication of this experiment is that Reality is Non-local. The result of measuring the polarization of a photon at one end of a laboratory is affected by the orientation of a polarizer at the opposite end. This result is a direct refutation of a tradition in science that predates Newton. Classical Locality entails the notion that we must act upon an object by sending some kind of signal. This kind of thinking in turn conjures up visions of "here" communicating with "there" by means of cogs, levers, wheels, light-beams and the like. The Aspect experiment has shown that, in the Quantum sense, the traditional thinking has been wrong. There are no completely autonomous, independent objects.

• Now, after the Aspect experiment, even seemingly local phenomena must be seen as occurring within the framework of a hidden substrate of Reality that is itself non-local. Action-at-a-distance, the bane of Newton and the mechanists of the 17th century, has returned triumphant. To an observer confined to examining the data at just one polarizer, the pattern of matches and mis-matches of photon polarizations will always be seen as random. Thus, the pattern he/she detects cannot be used to convey any faster-than-light message across the laboratory, (or the Universe for that matter). In short, no cause-and-effect relationship exists between the two detectors. Nevertheless, classical physics has lost its primacy, its finality, as a way of talking about the Universe. It is quantum physics that prevails. The World remains bound together as a kind of hidden Unity. Where does this leave classical physics? It is best seen as a kind of limiting case— one which becomes valid in the macroscopic limit, when quantum entanglements are blurred by the presence of too many interacting particles; its validity for us strictly a result of evolutionary history.

And how about the Quantum Theory? There are two very important points here.

• One is that the Aspect results are entirely consistent with every jot and tittle of the Quantum Theory. What was observed in Paris was precisely what Bohr would have predicted.

• Of equal importance is the second point: a careful look at Bell’s Theorem shows us that the Quantum Theory does not specifically enter into its underlying assumptions. Therefore, if the day should ever arrive when the Quantum Theory should be replaced by another, fuller theory, the results of the Aspect Experiment, together with Bell’s Inequality, will still guarantee that the Universe remains Non-local, perpetually entangled; and that, in the words of Nick Herbert:

...all systems that have once inter-acted at some time in the past...are joined in a manner unmediated, unmitigated and immediate.

This joining of systems is unmediated, because there is no intervening material medium; the joining is also unmitigated, because the connection does not lose its strength with increasing distance; and finally, the joining is immediate, because there is no mechanical signal that travels from the detector at the one end of the laboratory to the detector at the other, without traveling faster than light. In this manner we can see the essential Unity of the Universe, in which the divisions occur only by convention. In the
words of the logician G. Spencer-Brown:

We cannot escape the fact that the world we know is constructed in order (and thus in such a way as to be able) to see itself, but in order to do so, evidently it must first cut itself up into at least one state which sees, and at least one state which is seen.

Further Tales Of Einstein, Rosen And Podolsky.

After Aspect’s triumph in Paris, a ripple of excitement traveled across the surface of the little pond of physics. There is a certain tradition in science, one that dates from the time of Sir Francis Bacon, who as Lord Chancellor Of England, was the Chief Prosecutor of the Realm. Bacon held that it is necessary to question Nature in such a manner that she will be forced to yield up her answers, as if she were a defendant on the witness stand. Aspect’s experiment was of this kind, but it dealt with an Inequality. It asked the question: Is the correlation between the two-photon polarizations too large for “local realism”? (And indeed, of course it was.) But in England, at the University Of Durham, Lucien Hardy wondered whether it would be possible to entrap Nature in a manner that was more direct. Together with T. F. Jordan of the University Of Minnesota, Hardy concocted an ingenious line of questioning about polarizations—one which would involve definite answers instead of inequalities: an either-or situation. This felicitous idea was recently put to the test in the laboratory of Leonard Mandel at the University Of Rochester, by David Branning, Justin Torgerson and Carlos Monken16. If EPR were correct, one definite kind of answer would be given; if not, the answer would be radically different. Again the results of the experiment favored the Quantum Theory over the “local realism” of EPR—and this time by some 45 standard deviations. The game wasn’t even close.

Quantum Quibbles.

If you were determined to maintain that “local realism” were correct, and that the Quantum Theory were some kind of hoax, what kind of objections would you raise against Aspect, Branning and all their colleagues? The natural thing to claim is: “Foul!” “The dice are loaded!” And this is precisely what has taken place. That is, you would want to know if the polarizers and the photon detectors were uniformly sensitive at all angles, or whether there were not some kind of non-random error that biased the data in just such a way as to discredit Einstein’s “local reality”. You could claim that some malign agency blocks the arrival of photons at the detectors in just such a way as to support non-locality. This is precisely the tack that has been taken by a vociferous, but rapidly dwindling cadre of naysayers, the poor losers.

Winners And Losers.

A kind of “natural selection” has taken place in the past two decades. As a result of Bell’s Inequality, the only Quantum Interpretations that have survived are non-local ones. In particular, Einstein’s “ensemble theory,”17 the one which he defended so eloquently at the Fifth Solvay Conference, has become a notable entry in the fossil record. Therefore, the sign has now gone up over the door: “Only non-local theories need apply”. Clearly this is good news for the Copenhagenists; for the Copenhagen Interpretation is entirely in harmony with the developments that took place in Aspect’s laboratory. But we need to ask: Are there any other applicants? The answer is Yes. We shall discuss here three of the most interesting contenders.
In the year 1951, while Bohm held the post of Assistant Professor Of Physics at Princeton University, he wrote what is perhaps the clearest, most complete exposition of the Copenhagen Interpretation of the Quantum Theory. By disposition Bohm was a determinist, but he deferred to the awesome effectiveness of the Copenhagen Interpretation — an interpretation that has always managed to produce the Right Answer. Thus, by writing his book, he was really attempting to exorcise the demons of doubt from his mind. After considering the matter with care, he sent a copy to Einstein, who lived nearby. Einstein invited Bohm over to his house at 112 Mercer Street for a long talk. Later though, when his friend Murray Gell-Mann asked him how his audience with Einstein had gone in regard to the Copenhagen Interpretation, Bohm announced shamefacedly: “He talked me out of it”.

In subsequent years, in his wanderings across the globe, Bohm resurrected the long-buried theory of Louis de Broglie, which held that electrons are real, Newtonian particles, traveling smoothly through ordinary space, and guided by quantum “pilot waves”—the waves of a mysterious “Quantum Potential.” Inspired by de Broglie and Einstein, Bohm studied von Neumann’s “bible”, (see Ch. 11), in search of loopholes, and in time, he found one. Von Neumann had proved a kind of “Impossibility Theorem”, which stated in effect that, given certain “reasonable” conditions, there are no quantum states that are not statistical in nature. In plainer language, it means that there is no underlying local determinism in the Quantum Theory—no local “hidden variables”. But, Bohm asked what if, instead, the determinism were non-local? What if there was some non-local force distributed throughout the Universe, one that informed the electron instantly of any changes taking place, anywhere in the Universe? This force would guarantee the electron a classical trajectory, and guide it to its proper destination as in, say, the case of the Two-Slit Experiment. The computational problems involved in making calculations in Bohmian quantum mechanics are extremely daunting, but the development of modern computers has finally created conditions whereby Bohm’s theory could be tested. When Bohm’s computer printed its output graphically, there they were, the same fringes on the screen that you get from standard Quantum Theory! Bohm’s non-local quantum field could send a faster-than-light signal to the particle—at least in a computer simulation.

What’s Wrong With This Picture?

What are the weak points of Bohm’s theory? There seem to be a few, and they are definitely non-negligible. In the first place there is the mysterious Quantum Potential, supposedly permeating the Universe; a potential that, by some signaling process, guides the particle along a classical, deterministic trajectory. Since the Quantum Potential is non-local, the entire Universe must dance to its tune. But no one has ever detected a signal emanating from the quantum potential, acting to alter the motion of any particle. As you can imagine, it requires an exchange of energy to alter the path of a particle; but no sign of any energy exchange has ever been detected. Furthermore, the signal, supposedly having the power to deflect the particle, would have to travel faster than the speed of light. Last of all, when we consider an entity as tiny as an electron, (there is no experimental evidence indicating that its radius is different from zero), we have to realize that according to Bohm’s theory, the electron would have to be able to receive navigational signals from the Quantum Potential, decipher them, and change its state of motion accordingly. Thus every electron would have to be equipped with its own personal computer! Frankly, theories of this kind strain one’s credulity well beyond the Point Of No Return.
Newtonian mythology has a powerful grip upon Modern Civilization. Some of us insist that the world has to be visualizable, predictable, controllable—mechanical, at all costs. Many books have been written in support of this viewpoint. According to this theory, only particles, seen as autonomous, free-standing objects are real, (whatever that means!). Whatever the difficulties may be, the True Believer hopes that they can eventually be made to vanish. But embracing the universal determinism of David Bohm can be an embarassingly mystical experience for those who are clinging to the wreckage of the Western Rationalistic Tradition; for no particle is an island in Bohm’s world; what seems to be a particle is only a manifestation of Undivided Wholeness. An unfortunate feature of this interpretation of the Quantum Theory is that no one has ever been able to suggest a crucial experiment, a laboratory test, one that would enable us to choose between Bohm and Bohr. If it ever comes to pass, my money is on Bohr.

**The Parallel Worlds Theory, and The Garden Of Tsui Pen.**

In 1957 Hugh Everett III, a Princeton graduate student, produced a daring interpretation of the Quantum Theory, a heady brew which momentarily captivated the imagination of his thesis advisor, John Wheeler (!). In this theory, the Schroedinger function actually represents a particle, and not merely the probability of measuring its location. Instead of a collapse of the wave packet, the entire Universe exists in a state of continual bifurcation! In Everett’s explanation of the Two Slit Experiment for instance, when the particle is faced with the decision of which path to take, the Universe obliges, by dividing itself into two (or even more!) copies of itself. The wave packet never collapses; the worlds merely go on multiplying. This theory is a curious reprise of a truly great short story: *The Garden Of The Forking Paths*, written in 1944 by the Argentinian writer, Jorge Luis Borges. Everett’s theory itself has the important logical advantage of evading the problem of the collapse of the wave packet. Schroedinger’s cat remains both dead and alive, depending upon which Universe you (whichever ‘you’ you are) happen to inhabit. But there is a down side to the theory: it is extremely profligate with Universes, and universes are hard to come by. Furthermore, it is a theory that is untestable; for no one has ever convinced the psychiatrists that they have ever really been visitors in a Parallel World, and have returned. The crucial experiment remains to be found.

**Richard Feynman, And The Sum Over Histories.**

Incorrigibly original and creative, Richard Feynman, two full decades after Heisenberg and Schrödinger, provided yet another Interpretation of the Quantum Theory. What Feynman said, was that we can look upon the quantum entity as taking every possible path available to it. To find the probability that the entity will be detected as a particle at some point, we “sum over the paths” of the “amplitude” (akin to the Schrödinger function) for all possible paths that the quantum entity can take, starting from its initial point. These amplitudes have phases attached to them, as waves do, so that they add, sometimes in phase, sometimes out. With respect to the Copenhagen Interpretation, a certain similarity exists. Neither interpretation purports to reveal The True Nature Of The Universe, or any other superfluous ontological baggage. Both Interpretations are essentially algorithms: recipes for calculation—and both of them yield the same answers.

**If We Are Tired Of Shopping For Interpretations, What Can We Conclude?**

In the first place, modesty is essential. One should be suspicious of ontological theories—ones that
purport to reveal: “the way the world is”. One must also realize that physics always carries a heavy load of metaphors. Later, we shall see that the word “particle” is one of the most unreliable of these, since it has been allowed to go unexamined for so long. Personally, I am skeptical after having been exposed to a surfeit of ontological models. Therefore I am grateful for the simplicity of a Bohr or a Feynman, physicists who offer me an algorithm instead of a world-view. The history of world-views hints strongly that they are ephemeral, like fashions in clothing. Today the Quantum Theory remains the most successful theory in history, but Bohr reminds us that:

There is no quantum world. There is only an abstract quantum description. It is wrong to think that the task of physics is to find out how nature is. Physics concerns only what we can say about nature.

Perhaps Erwin Schroedinger should have the last word here, at least in the matter of the rivalry of determinism versus indeterminism in the workings of Reality:

Henri Poincaré explained that we are free to apply...any kind of...geometry we like to real space.... The same statement probably applies to the postulate of rigid causality. We can hardly imagine any experimental facts, which would finally decide whether Nature is absolutely determined or is partially undetermined. The most that can be decided is whether the one or the other concept leads to the simpler and clearer survey of all the observed facts.

What Can We Conclude So Far From Our Study Of The Quantum Theory?

1) What we have is a tool, a recipe—an algorithm: Schroedinger's equation seems to furnish us with infallible predictions concerning the odds on the outcome of our measurements; e.g., digital displays or pointer positions.
2) There is no description available of any deeper reality--any explanation as to why the outcome of our experiment turns out to be what it is. Why does the pointer point to that number? We cannot tell why it has to be this way, for we have no picture.
3) Further, the framework of our traditional, classical, common sense view of the world is forever broken. By this I refer to two of the three assumptions of Bell's Inequality:

   (a) Locality: the idea that objects are localized, so that their effects radiate outward from them to neighboring objects; that they can act only in a causal way upon each other, and then only be mechanical means such as the exchange of light signals.
   (b) Realism: the idea that phenomena we observe are the result of some independently existent reality. From experiments, we have seen that locality and realism cannot be features of the world, but rather as it is understood by means of the Quantum Theory.

You might be interested in how I got involved with this fascinating material. I started to have questions about the subject of polarization when I was an undergrad at UC Berkeley in the late 1940’s. But all the people around me seemed so competent and self-assured that I assumed that I was an ignoramus. Later my doubts bubbled back to the surface when I happened to hear Boris Podolsky speak about the EPR theorem in 1962. But the years rumbled by, until the 1970’s, when a friend gave me a copy of a
magazine article that told of a group of hippie scientists haunting San Francisco coffee houses, discussing something called Bell’s Theorem. My heart beat faster. And then, in 1979 I read an article in Scientific American, by Bernard d’Espagnat, describing a possible experimental test for Bell’s Theorem. (Actually d’Espagnat was a kind of guru for Aspect’s team—and he also commuted to San Francisco to confer with the hippie scientists). It was great time to be alive! Recently a book has come out, telling about the San Francisco crowd, and helps us to relive those times vicariously, its title is How The Hippies Saved Physics, by David Kayser, of M.I.T. A Great Read! It is so good to be able to hoist the “Jolly Roger” and successfully challenge the Dominant Paradigm.

A final note: In the original text for my course, this chapter was followed by one entitled: A Journey To The East, an application of The Quantum Theory to “particle physics.” That chapter has been demoted to Appendix F, since I am not teaching physics classes any more.

Notes to Chapter Twelve:
(1) The Institute For Advanced Study, located in Princeton, New Jersey, is not affiliated with Princeton University. It is an independently endowed institution, one that has been, at one time or another, home to some of the best scientists and mathematicians of the twentieth century.
(2) The paradox arises, of course, from the fact that Einstein was one of the Founding Fathers of the Quantum Theory, and had subsequently turned against his own offspring. Perhaps an explanation lies in the fact that Einstein always revered the teachings of the 17th century philosopher Benedict Spinoza, whose deterministic philosophy is evident in the epigraph at the heading of this chapter.
(3) The law of Conservation Of Momentum states that, in the absence of any external force, the momentum of a system stays the same. Therefore, if the particle is initially at rest and then breaks into two pieces, the total momentum of the two pieces is still zero.
(4) What is more, one can measure the position of the second particle, and thus be able to infer the position of the first one. In this manner the Uncertainty Principle is violated. Fortunately that hen won’t peck.
(5) A ping-pong ball with “english” on it, is a classical example of “spin-angular momentum”. Quantum spin-angular momentum is much weirder, because the spin-angular momentum is severely quantized, and we can know its value only along one direction at a time.
(6) Local Realism = Einstein Locality + Realism.
(7) For more about this fascinating topic, read the article: The Quantum Theory and Reality, by Bernard d’Espagnat, in Scientific American, November 1979. Even better is a wonderful discussion of the whole affair in the book: Quantum Reality, by Nick Herbert, Doubleday Anchor Books, 1987, Garden City, NY. At this moment: (April 2014). I am preparing to place a version of this book on a Website, and there are (inevitably) other books that I wish to recommend. One of them is: Boojums All The Way Through, by N. David Mermin, Chapter 12, Cambridge University Press, 1990.
(8) Aspect, (pronounced: As-peh), like Bell and Bohm, had believed that Einstein was right. What a surprise it was to find that Einstein was wrong! It’s like being taught all your life that the world has a picket fence around it—and then discovering that it isn’t there!
(9) Polaroid sheets are not exactly 100% efficient, but they are pretty good. Better yet is a crystal of calcite, but a discussion of the properties of this marvelous mineral is beyond the scope of this book. See: Quantum Physics, Illusion or Reality, by Alistair Rae, Cambridge U. Press, 1986.
(10) The law of polarization was discovered in the 18th Century by Etienne Malus, who detected the polarization of light one afternoon, watching the sunlight as it was reflected from the windows of the Palais du Luxembourg in Paris. That night he worked out the details, using pieces of glass and the light
of candles. Briefly, the intensity of light, which has passed through a pair of polarizers (like polaroids, for instance) varies as the square of the cosine of the angle between the two axes of polarization. This is the Law Of Malus.


(12) This idea is important. Photons are hard to count. The efficiency of a modern photon detector is on the order of 50%, comparable to the photon efficiency of the human eye. The “cascade” is one of the two reliable methods of obtaining single, countable photons.

(13) It should be noted that photons are not really green or blue; they really have no color at all. Color is a quality that requires a perceiver. It is, put simply, our physiological reaction to certain wavelengths of the electromagnetic spectrum. I am deliberately over-simplifying.

(14) I say: “at most”, for if the left- and right-hand polarizers both produce a “mismatch”, the mismatches will have cancelled each other out. **This** is the reason we have an inequality. The combined mismatch is **at most** equal to 50%.

(15) More than 50 years before the Aspect experiment, Erwin Schroedinger, in studying what Quantum Theory predicts in the case that two particles interact at any point in time, noted that their Schroedinger wave functions will remain forever **entangled**. Evidence from astrophysics indicates that at the moment of the Big Bang, the Universe was confined to a tiny region. Therefore everything therein was at one time interacting closely with everything else. From this it is hard to escape the conclusion that the Universe has no “parts”—that its wave function is permanently entangled.


(17) Remember, Einstein believed that particles in a Two-Slit Experiment behave in a manner similar to people. It is possible to predict their behavior statistically, even though our knowledge of their individual lives is unavailable. Einstein assumed that there were deterministic hidden variables that were local in nature, and that the probabilistic character of quantum mechanics is merely an expression of **our** ignorance—of something that is really, objectively, **THERE**. Theories of this kind can’t even explain the results of the Delayed Choice Experiment, but the Aspect experiment **administers the coup de grace**.


(20) Borges’ works appear in innumerable anthologies. The stories are all short, extremely compressed, and contain themes that have been employed by subsequent authors. Borges’ stories are of the variety that “makes the walls to vibrate”. Don’t miss them! The Garden Of The Forking Paths appears in translation in *Ficciones*, Grove Press, NY, 1962. It can also be found in: *Labyrinths; Selected Stories And Other Writings Of Jorge Luis Borges*, Grove Press, New Directions Paperback, New York, NY, 1964. After reading a dozen or so of the works of Borges, one gets the feeling that his view of the world is the preferred view, just because it is so interesting.


(22) See: *QED, The Strange Theory Of Light And Matter*, by Richard P. Feynman, Princeton University Press, 1985. These lectures were given in memory of his friend, Professor Alix Mautner. Feynman had made a promise to her to explain his theories in such a simple manner that a person having no scientific background could understand them. Several rungs above QED in difficulty, but still clearly written, is the book: *Quantum Mechanics And Path Integrals*, by R. P. Feynman and A. R. Hibbs, McGraw-Hill,
New Chapter Thirteen
A Matter of Consciousness

Realizing that the physical world is entirely abstract and without actuality apart from its linkage to consciousness, we restore consciousness to the fundamental position instead of representing it as an inessential complication...To put the conclusion crudely—the stuff of the world is mind-stuff...The mind-stuff is not spread in space and time; these are part of the cyclic scheme ultimately derived out of it.

Sir Arthur Eddington

Since the title of my original course was “The Conscious Universe,” it is only fair to demand why it is that we should consider the universe to be “conscious.” To this I reply with the questions: “Do you consider yourself to be conscious?” “Are you part of the universe?” There may be some who will, from sheer stubbornness, answer in the negative; thereby excluding themselves from any further meaningful discussion. But we are all of us, obviously, conscious, in the sense of being aware—at least some of the time. By the way, since we are part of the universe, when we think about the universe, does this not imply that the universe is also thinking about itself? And is this not analogous to the famous Morits Escher lithograph, entitled ‘Drawing Hands,’ which depicts a pair of hands, each one holding a pen, while drawing the other hand. Thus the universe is self-referential! In this sense of the word: ‘consciousness,’ can we also extend it to other members of the animal kingdom? It certainly seems so. How about plants? I would ask: “Is there any evidence that plants communicate with one another?” Some experimenters claim that this is also indeed the case. In the context of this discussion, it would not be surprising.

But there is one more possibility. I consider it entirely possible that consciousness is not localized—that it is a kind of field that pervades the universe. Thus considered, consciousness is not itself a product of the universe, but the other way ‘round. It is rather the universe that is a product of consciousness! The universe, to this way of thinking, is not “stuff”; it is really a kind of information. The great physicist, John Archibald Wheeler, described this idea pithily: “It from bit,” where the word: “bit” comes to us from Information Theory; basically, it is the difference between 0 and 1, in binary notation.

The Bar Code

Suppose I go to the store to buy a candy bar (dark chocolate, 85% cacao). On the wrapper is printed a bar code, containing the information necessary to identify this item to the scanner at the checkout counter. For the field quanta that characterize the universe, there is also a bar code. In Appendix F you will find that the electron is (not ‘has’), a bar code. Let’s enumerate: (1) the charge, (2) the mass, (3) the
angular momentum, and (4) the coupling to the Weak Force. But there is no “candy bar.” Strip away any of those quantities and there is no electron, either! It sounds bizarre, but we must practice saying this to ourselves several times a day: “It From Bit!”

**The Conscious ‘Unconscious’**

During the 1880’s a group of researchers studied what they called “hysteria” at a hospital in Paris. Among their number were listed some famous names: Charcot, Binet, Janet, Babinski, but the most famous of them was a Viennese neurologist named Sigmund Freud. It was he who is said to have discovered the Unconscious. What he found was that that our so-called ‘unconscious mind’ is aware (conscious!) of many more things than we claim to be ‘conscious’ of. What we are aware of in our daily lives is only the ‘tip of the iceberg.’

**How The Brain Seems To Work: The Brain As A Reducing Valve**

*If the doors of perception were cleansed everything would appear to man as it is, infinite. For man has closed himself up, ‘till he sees all things through narrow chinks in his cavern*

*William Blake, The Marriage of Heaven and Hell (1793)*

More than a century ago the philosopher Henri Bergson pointed out that one of the major functions of the brain is that of filtering out the overwhelming deluge of useless and irrelevant knowledge with which we are constantly inundated, in every second of our lives. In his book *The Doors Of Perception*, Aldous Huxley expressed this idea in the following fashion:

*According to such a theory, each one of us is potentially Mind At Large. But insofar as we are animals, our business is at all costs to survive. To make biological survival possible, Mind at large has to be funneled through the reducing valve of the brain and nervous system.*

In Huxley’s view, (a view very similar to my own), all of our experiences are creatures of a colossal Mind: ‘Mind at large.’ In this view we can apparently set up a ratio: “Consciousness is to our individual awareness as Life, (a grand tapestry, billions of years old, extending across the universe) is to our own individual lives.” And based upon the experience of many individuals, there exists a vast reservoir of knowledge, one that is free to impinge upon our defenseless brains, independently of our senses. Therefore, we must be able to “dial out” most of the signals that we receive, simply to enable us to carry on our everyday pursuits—such as commuting to work, etc. In this view, instead of *producing*
consciousness, the brain seems to function as a receiver of consciousness, one that must reduce the flow of consciousness to “a measly trickle,” so that we may be able to function in our role as animals.

What a fascinating insight! The brain seen as a sphincter! While working on the previous version of this book I read several articles supporting the sphincter theory, ones that hinted about the reticular formation and the raphe nuclei, located on the brain stem, and their uncanny ability to “sort the incoming mail.” But new information has now come in, bringing us yet another scenario.

A great number of mental activities wind up falling into the category of “on automatic pilot.” At the onset of one of these unconscious mental excursions we begin to build up chains of neurons, and these chains become richer and stronger with repetition, (i.e., they recruit more neurons). In time those neuronal pathways come to operate independently of any supervision provided by our frontal lobes, which might subject their activities to useful criticism. Advertising works in this manner, “under the radar,” and it is remarkably effective.

My point: most of our mental traffic takes place along these heavily traveled neuronal pathways, ones that operate in a manner similar to superhighways, and it is just the noise of this traffic that appears to block out the messages from ‘Mind At Large.’ This version of the story seems to be harmonious with what is observed in brain scans, and therefore it appears more relevant than my previous one. Now let’s look at the research upon which this story is based:

The following excerpt has been taken from an article that appeared in Science News of 25 February 2012 Vol. 181 #4.

There is a psychiatrist and neuropharmacologist at Imperial College, London, named David Nutt. He recruited fifteen people with previous experience with what he called: ‘hallucinogens,’ and injected them with “a small amount of psilocybin”—and scanned their brains. The result: reduced blood flow, most pronounced in the hubs that connect different parts of the brain, (i.e., superhighway interchanges). The science writer, Devin Powell, stated that: “it fits with how Aldous Huxley described the effects of mescaline.” Exactly!

“Decreasing the activity in certain hubs of the network may allow for a more unconstrained conscious experience,” says Matthew Johnson, an experimental psychologist at Johns Hopkins University School of Medicine in Baltimore, who studies psilocybin and other ‘hallucinogens.’ “These drugs may lift the filters that are at play in terms of limiting our perception of reality.”

Further work by Nutt’s team showed that the brain hubs responded together, linked by a neural circuit, called the “default mode network.” Some scientists believe that this highly
interconnected brain superhighway is essential for maintaining a person’s sense of self. We have discovered something that we already half-knew. Too much traffic clutters the mind! Furthermore, when we look for the ‘self,’ it turns out to be elusive. I hope to write about this, and to get it online.

Johns Hopkins University is the center for much good work with psilocybin, as is also NYU; the researchers at these institutions are finding this substance to be of great merit in end-of-life situations. While Aldous Huxley was dying of cancer, his wife gave him LSD by injection, and the result was a very positive one. In his last note to her his request was: “More LSD.”

**Does Consciousness Create Reality? Two Reasons From Quantum Mechanics**

Let’s have another look at the Delayed Choice Experiment (Chapter Eleven). As in the two-slit experiment, we could make the photon manifest itself either as a particle or as a wave. But in this case we make this decision *after* the photon has already passed through the slits. So our conscious decision taken in the present has altered the state of affairs in the past! Please note, as this is really weird. Would that we could do this in our daily lives!

We are accustomed to taking a 19th century view of space and time. We think of time as a flowing river, carrying us inexorably from the past into the future, passing through the present. But this is not what happens in the Delayed Choice Experiment; here we have written history retroactively. There is also something strange about what quantum mechanics has to say about space. In the Aspect experiment (Chapter Twelve) the orientations of the polarizers change very rapidly, rapidly enough so that a light signal does not have time to be transmitted between them. Thus the state of two entangled photons is established, as far as we can tell, instantaneously! This would still be the case, even if the photon detectors were located galaxies apart, or at opposite sides of the universe. Hence time and space are not as ‘real’ as we have been conditioned to think they are.

There is a more recent experiment, the results of which are more radical. In the year 2002 Nicolas Gisin used optical fibers to transmit entangled photons over a distance of ten miles at Geneva, Switzerland. A change in the polarization state of one photon produced a corresponding change in the state of the other, and as nearly as we can tell, the change was instantaneous. If the photons had been sending messages to each other, it would need to have occurred at ten million times light-speed!

So, it doesn’t matter if the two entangled photons are separated by zero distance or by a billion light years. What, again, is the importance of space and time, when they have no significance to entangled quantum states?

The only explanation that I can conjure up shed light on the anomaly is this: there is a bifurcation in
reality, as we are forced to view it. Before making our observation we use the rules of quantum theory.

The quantum probability of locating a ‘particle’ is that of finding a moving blob in a space having no fewer than seven dimensions: (three spatial ones, x, y, and z, three dimensions in momentum space: p_x, p_y and p_z, and last of all, time). At the moment of observation, (an event) a radical discontinuity occurs. For just an instant, (before Schrödinger’s equation starts to crank forward again), we are not observing a quantum probability; we are observing the only kind of thing that we ever observe: not a ‘thing’, but an isolated event! It is the context that has changed. Perhaps the meaning of space and time changes with context! On the quantum side of the ledger nothing over there can be said to ‘happen.’ ‘Happening’ is a property of events. Events are observations! This should enable ‘time’, at least, to claim some exotic properties. Further, the quantum wave function has a twin, one that is entirely equivalent, and which propagates backward in time. So, we have a lot to learn about this subject. Space and time are of concern only after the observation or measurement has taken place. So it is not surprising if it doesn’t apply to the wave function in the same manner that it applies to the cannon ball.

And Now For Something Really Strange

Here is what R.P. Feynman said about the two slit experiment: “I will take just this one experiment, which has been designed to contain all of the mystery of quantum mechanics, to put you up against the paradoxes and mysteries and peculiarities of nature one hundred percent....”

It’s time to go back for a look at the two-slit experiment, using photons. The photon encounters two slits, interferes with itself, and produces an interference pattern on a screen placed behind the slits. Any attempt to ascertain the ‘path’ of the photons promptly destroys the interference pattern. What would happen if someone were to concentrate, and to become conscious of the beam of photons as they ‘pass through the slits’? Would this affect the outcome of the experiment? This experiment has actually been performed, and the result so far is not merely interesting, it is downright fascinating!

Remember: the problem of quantum measurement was addressed by the great John von Neumann in his book: *The Mathematical Foundations of Quantum Theory*. He traced the chain of collapse of the wave function, from the laboratory situation all the way to the human brain, and concluded that it was human consciousness that causes the wave function to collapse. But if this is correct, it is possible to push our reasoning a bit further. To measure, to observe: this requires a decision--human intention. Intention requires consciousness. If this type of thinking is correct, then intention must have an effect upon the wave function!

Now let’s apply this line of thought to the double slit experiment. Remember, if we try to find out which slit the electron went through, the interference pattern will disappear—at least to the extent that we are successful in observing the path chosen. Fine! Suppose that we concentrate, from a distance, on the electron beam, and express our intention of knowing which path the beam took. What would happen
then? Fortunately, we can attempt to find an answer, for this experiment is presently in progress! And you can even join the experimenters! All you have to do is just open the following website:

www.ionsresearch.com

…And start reading.

The contents of that website are amazing; it contains several brilliant videos on the topic of the double slit experiment. An experiment of the kind that Dean Radin is performing falls into a category that we call psychokinesis, a type of activity that never fails to bring out platoons of slavering witch-hunters. It is a clear example of those ‘spukhaften Fernwirkungen’ (spooky actions at a distance) that were so hateful to Einstein. To be able to exercise this kind of power upon the double slit experiment is to participate in one greatest on-going experiments of all time! (It’s even more important than finding the Higgs particle, and much cheaper, too). At the start of the 19th century Thomas Young used it to demonstrate the wave nature of light. About sixty years ago two fine researchers showed that electrons could exhibit the same pattern. And now, you can be one of the participants in an experiment, showing that human consciousness actually affects the result, thus “collapsing the wave function.” The spirit of John von Neumann would beam upon you. Radin earned his bachelor’s degree in Electrical Engineering and his doctorate in psychology from The University of Illinois, so his academic qualifications are clearly of the highest sort. Radin reports that his volunteers have produced “significant results,” so it is important that many recruits be assembled, in order to produce as much data as possible. An abundance of data points is called: ‘statistical strength’: the Holy Grail of science.

Social Control

At this point it is necessary to talk about a subject that makes everyone uncomfortable. To keep the discussion on neutral ground I shall discuss a case that comes from the annals of ‘straight science’: the story of the tribulations of Michael Polanyi. The story appeared in the book *Paradoxes of Progress*, by neurobiologist (and colorful character) Gunther Stent. In the early years of the 20th century it had become noticed that gas molecules tend to stick to metal surfaces: a process called adsorption. In the years 1914-1916 Polanyi developed a theory that described adsorption, based on actual measurements made in the laboratory. In spite of its being based solidly upon experimental evidence, Polanyi’s theory was vehemently rejected. In the words of Gunther Stent: “Not only was the theory rejected, it was also considered so ridiculous by the leading authorities of the time that Polanyi believed continued defense of his theory would have ended his professional career if he had not managed to publish work on more palatable ideas.” (I guess he was afraid that they wouldn’t let him use the voltmeter any more). To appreciate the power that the herd exerts over the minds of its members it is sufficient to read this groveling statement by none other than Michael Polanyi himself.
This miscarriage of the scientific method could not be avoided…. There must be at all times a predominantly accepted scientific view of the nature of things, in the light of which, scientific research is jointly conducted by members of the community of scientists. A strong presumption that any evidence that contradicts this view is invalid must prevail. Such evidence has to be disregarded, even if it cannot be accounted for, in the hope that it will eventually turn out to be false or irrelevant.

(It sounds just like religion, doesn’t it? Sunday school! Yuck!) Professor Stent follows the above quotation with a concluding remark about this affair.

That is a view of the operation of science rather different from the one commonly held, under which acceptance of authority is something to be avoided at all costs. The good scientist is seen as an unprejudiced man/woman with an open mind who is ready to embrace any new idea supported by the facts. The history of science shows, however, that its practitioners to not appear to act according to that popular view.

This question has troubled me for at least fifty years, and I would like to give you what I believe to be a possible explanation for why it is that otherwise intelligent human beings allow themselves to behave in this manner. In short, it is a disease that is common to all organizations: national governments, corporations, churches, clubs, and of course, the ‘scientific community.’ The organizations’ founders usually have the best of intentions, and consider their creations to be ‘a force for good in the community’ (as we used to say). Time passes, (and it doesn’t take long), before the organization becomes an end in itself, its original raison d’etre becomes lost in the deadening routines of daily life. In time the organization (depending on its identity) will have awarded fellowships, professorships, generalships, bishoprics, and lots of medals. And inevitably sclerosis happens. (Technically, these are social forms, and they imply ‘social control’). People keep going through the motions, but they have lost track of why they were supposed to be there in the first place.

I can’t remember Max Born’s exact words, but what he said seems to have implied that new ideas will only gain acceptance, at the rate of one funeral at a time. I’m afraid he was optimistic. But our problem is not a scientific one; it constitutes the final stage of any society: moribundity. I find it impossible to avoid comparing our present day society to other, long-defunct human enterprises: the ones that have given us pyramids and cathedrals—soon to be joined by skyscrapers and sports stadiums—excellent projects for tomorrow’s archeologists.

In the following chapter we proceed bravely into the eye of the storm. Contrary to what you have probably been told, mountains of data have been accumulated on various types of ‘spukhaften
Fernwirkungen,’ phenomena that are generally called ‘Psi.’ What I shall do in the course of Chapter Fourteen is (1) to give a brief overview of the various phenomena, together with a presentation of the data, and (2) to give a short list of books by people who have actually done serious research in this field. At one time I studied under a French professor, who announced to the class: “You must do ze ‘omeworks!” The books I list fall into that category. I am satisfied that these people have indeed done ‘ze ‘omeworks.’
Chapter Fourteen
Psi-What are the data?

If you wish to upset the law that all crows are black, you must not seek to show that no crows are black; it is enough if you prove one single crow to be white.

William James

No doubt you would far prefer that you would hold fast to a moderate theism, and turn relentlessly against anything occult. But I am not concerned to seek anyone’s favor, and I would suggest to you that you should think more kindly of the objective possibility of thought-transference and therefore also of telepathy.

Sigmund Freud

When people talk about ‘psychic’ phenomena, they generally try to place them into one of four major categories: telepathy, clairvoyance, precognition and psychokinesis. This system of categorization is far from exhaustive, but it will serve our purposes. We shall be using the following rough definitions.

1. Telepathy: The ability to sense from a distance the feelings of another person. Another way to describe it is: thought transference.
2. Clairvoyance: The ability to visualize distant or hidden objects.
3. Precognition: The ability to sense an occurrence in advance.
4. Psychokinesis: The ability to exert psychic influence on an object.

In history there have been a large number of extemporaneous examples of the occurrence of these phenomena.

Following are two examples of what is very possibly precognition. There are a lot of stories of this kind-ones that have an unmistakable eeriness about them.

A most interesting example occurred recently, and concerns the tragic events of 9 September 2001. In her excellent book: The ESP Enigma, Diane Hennacy Powell points out that, on the four planes involved, the occupancy level was far below normal. At the time, the average rate of occupancy on airline flights was 71 percent. On the four doomed flights on that fateful day the percentages were: 51, 31, 20 and 13.

One day in the summer of 1983 my wife and I drove from New Jersey to East Haven, Connecticut to visit a friend. As we started on the return trip that night my wife unaccountably insisted that we take different route on our return. Upon reaching our New Jersey destination we learned that the bridge we had crossed on the way to East Haven had collapsed that night, killing several motorists.

As interesting as we find these stories to be, they fail to answer the most important question: Are Psi phenomena real? What we need to do is to construct a kind of experiment, one that will give one kind
of result if a Psi phenomenon is present, and a different one if Psi is absent. And once we have constructed and performed this experiment, we will need to find a reliable method for displaying and interpreting our data. This requires that you acquire a grasp of a couple of the fundamental ideas in Statistics.

Let’s start by tossing a coin four times. And let’s assume further that the result of all four tosses is: ‘heads.’ The probability of such an outcome is 1/16, implying that the odds in favor of this happening are small—but not unheard of. We should expect something of this sort to happen 6.25% of the time. But common sense tells us that the most likely configuration is one of two heads and two tails; the latter should, (absent Psi), occur 6/16 of the time, or 37.5%. But with only four coin tosses, a run of four heads still falls within the limits of what can occur by chance. What to do? Answer: We need lots of data! We need to toss that coin thousands of times. If we do so, (absent Psi), we should get a distribution of five items, representing the relative frequency of heads and tails. It will look like this: 1,4,6,4,1. If our distribution looks different from this, then we will need a practical criterion that will tell us if it is safe to conclude that there is a reason to suspect that some ‘spooky action at a distance’ is a-foot. The criterion used in the social sciences is this: The event in question must be one that is expected to occur by chance, less than five percent of the time, when the experiment is repeated many, many times. This called a 95% ‘confidence limit.” On a graph of our experimental results this limit is displayed by an ‘error bar.’ If the result differs from this criterion, then the next question is: By how much does it differ? How far outside the limit does it lie? What I have tried to describe here is our first fundamental idea in statistics.

In his book: *The Conscious Universe*, (pure coincidence), Dean Radin gives a very useful example. When I was young, there was a very fine outfielder for the New York Yankees named Mickey Mantle. In any given season one can compute his batting average. Mantle would have compiled perhaps 300 at-bats in a season, so the calculated batting average would give an accurate picture of his prowess as a hitter. And sure enough, the “error bars” will testify to this fact—one for each of the seventeen years that Mantle played.

But here is an exciting new idea! Suppose we consider every hit for Mantle’s entire career, and divide this number by the total number of at-bats. The resultant figure is Mantle’s lifetime batting average: .290. The important feature is the size of the error bar: it is very small. The 95% confidence limit is quite small, meaning that we know the number quite accurately. Why is this? For any given season he may have gone to bat 300 times. But over his career he may have gone to bat nearly five thousand times! All these extra data points give us a much better fix on Mantle’s performance.

And this is the whole point: This technique has applications far beyond the realm of baseball! Social scientists often use it. And it is useful in Psi. *It is called meta-analysis.*

A skilled statistician can use this to meld together the data from several experiments, performed at different times, by different experimenters—into one giant meta-experiment—a technique called *meta-analysis*. Dean Radin includes, as an epigraph to the chapter on meta-analysis in his book: *The Conscious Universe*, a quotation by philosopher David Chalmers: “[Meta-analysis] is going to revolutionize how the sciences...handle data. And it’s going to be the way many arguments will be ended.”
During the 1970′s and 80′s a great deal of work was done at the Maimonides Dream Laboratory in New York, by Stan Krippner and Montague Ullman. In a typical Dream Telepathy experiment the subject, who has become acquainted with the other participants in the experiment, is sleeping in a locked room and is connected by wires to a monitor, one that detects rapid eye movements. This phenomenon (REM) signals that the sleeper is in a dreaming state. The information is transmitted as a signal to an Operator, located in a room down the hallway. Upon receipt of the REM signal from the sleeper, the Operator transmits a signal to a person called the Sender, who is waiting in another isolated room, at the far end of the building. Upon receiving the signal from the Operator, the Sender takes the target—usually a photo or an art reproduction selected by a complicated randomization procedure—from a sealed envelope. The Sender concentrates upon this image, attempting to transmit its contents to the person who is asleep. Then, at the end of the REM period the Operator wakes the Sleeper from her/his sleep and asks for a description of the dream. At the end of the experiment a panel of independent judges compares the dreamer’s description with the Sender’s material, scoring the description on the basis of similarity between the two.

From the first, these experiments were quite frustrating. The accumulation of data was a very time-consuming process, tending to result in poor statistics, since the statistical ‘strength’ of the experiment depends crucially upon the number of trials. This frustration was compounded by the fact that some of the individual performances were of outstanding quality—that is, the content of the dream corresponded closely to the picture that had been viewed by the Sender. Despite these difficulties, during the period between 1966 and 1973 a total of no fewer than 450 Dream Telepathy sessions were reported, with very impressive results: an average score of 63%, compared with 50%, (representing ‘pure chance.’) As we shall see, the Maimonides experiments represented only the beginning of a very fruitful line of inquiry.

Another Epidemic of Groupthink

Normal science, for example, often suppresses fundamental novelties because they are necessarily subversive of its basic commitments.

Thomas Kuhn
The Structure of Scientific Revolutions

The Maimonides Dream Telepathy experiments had an interesting sequel. It’s only natural to inquire about the response of the psychological community to the work of Krippner and Ullman. Irvin Child, Professor of Psychology and Department Chair at Yale University asked the question, and proceeded to examine psychology textbooks in which these experiments had been mentioned by the authors. Astonished by the biased and unfair treatment accorded the Maimonides study, Child concluded that the books he had reviewed contained “nearly incredible falsification of the facts about the experiments.” The kind of ‘mental inattention’ whose symptoms were uncovered by Professor Child, is in fact far more widespread than I can address in a necessarily short treatment. My best source of information is Dean Radin’s The Conscious Universe.
The Ganzfeld Experiments: the gold standard in telepathy

In the mid-nineteen seventies, as the Maimonides studies were winding down, Charles Honorton, one of the researchers on the project, found himself wondering how to produce a “psi-conducive” state without the cumbersome time-consuming set-up required by Dream Telepathy. He felt that perhaps this could be achieved by simply reducing the sensory input to the person acting as the subject in the experiment. Almost at the same time, a similar line of thought was being followed by William Braud at the University of Houston, as well as Adrian Parker at the University of Edinburgh. The three men had all noticed that descriptions of mystical, meditative states often include anecdotes about spontaneous psi experiences. This led them to reason that perhaps some sort of sensory deprivation would turn out to be a solution to the problem.

Therefore the three researchers set themselves to the task of reducing the inputs from sight and hearing, since our richest sources of sensory distractions are those things that we see and hear. To reduce visual input, halved ping-pong balls are taped over the subject’s eyes, and the entire visual field is flooded with diffuse red light. To remove extraneous sound, earphones are placed over the ears, and the subject’s auditory field is flooded with pink noise (a kind of hiss, with the higher frequencies filtered out). Since the essence of the method requires that the entire visual and auditory field be therefore blocked, this technique has been called “ganzfeld,” after the German word for “entire field.”

To carry out a ganzfeld experiment three steps are necessary: (1) preparing the Receiver and the Sender, (2) sending the target to the receiver, (3) judging the outcome. This method has the advantage of keeping separate the sender, receiver and experimenter, so that no subliminal cueing can occur: ‘no cross-talk between channels.’ As one might expect, the ganzfeld experiments are much more efficient in the expenditure of person-hours than were the dream experiments.

Earphones and ping-pong balls in place, the psychic Receiver is put into the ganzfeld state using the method described above, while a progressive relaxation tape is being played through the earphones to produce the proper ‘mood.’ A computer automatically selects a target to be given to the Sender, who has meanwhile been escorted to a distant, isolated room. The Sender now views the target on a video screen and tries to ‘send’ it to the Receiver. Afterwards, the Receiver, whose every word has been recorded for research purposes, is shown four video clips, and is asked to rate them according to how closely they match his/her impressions during the ganzfeld transmission period. Thus, if the Receiver were to pick the correct video clip on one occasion out of four, (25% of the time), the result would be no better than ‘chance.’ However, Honorton’s results in his 1985 experiments indicated a hit rate of 37%--a very significant deviation, as we can see from figure 14-1, which describes the result of a meta-analysis of several ganzfeld experiments. The value of meta-analyses can be seen from the extremely short error-bar at the right of the figure.
Shortly after completing this experiment Honorton encountered Ray Hyman, Professor of Psychology at the University of Oregon. Hyman, a deep-dyed mechanistic ‘skeptic,’ had earned his reputation as ‘Devil’s Advocate’ in the world of parapsychology. Honorton challenged him to help design the Totally Foolproof Ganzfeld Experiment. Hyman accepted that challenge, and the two of them obtained a hit rate of 32%, relative to the usual 25%, representing a chance outcome.

You, the reader, looking for happy endings, will ask: “Were these results sufficient to convince Professor Hyman that the phenomenon is genuine?” I’m afraid that the answer is ‘No.’ In Radin’s excellent account, Hyman claimed to detect randomization flaws, which he felt had a significant relationship with the outcome of the study. To Hyman’s discomfiture, when the matter was reviewed by a panel of ten statisticians and psychologists, not one of them agreed with him.

At this point you may wonder why it is that people act this way. I, too, have wondered about this kind of thing, (ever since I was nine years of age). As a psychologist Dean Radin seems to be fascinated by symptoms of this kind of pathological thinking also, for his three books on the subject all contain references to the antics of the ‘skeptics.’ To be skeptical of theories is praiseworthy, but to persist in skepticism in the face of an avalanche of data, is a sign that indeed, something weird is going on, and that the human mind is not to be trusted. Just show me the data!

What are the data? In 1994 Charles Honorton of the University of Edinburgh and Daryl Bem of Cornell University performed a meta-analysis of ganzfeld experiments in which the odds against chance came out at 48 billion to one! Professor Bem, up to that time a real skeptic, changed his opinion of Psi as result of what he learned.

**The Feeling of Being Stared At**

The feeling that someone is staring at you is one of the most widespread verifiable examples of an uncanny experience. Various researchers have found that 70 to 85% of a given population will report having experienced this sensation, only to turn around and discover a pair of eyes staring fixedly at
them. In the year 1913 the psychologist J.E. Coover made a mail survey of respondents in California, and obtained similar results.

Later that year Coover attempted to verify this experience in a laboratory setting, by having his subjects report whether they were aware of being stared at. To his chagrin, he found that the results of the experiment were no better than what might be expected from chance. Later experiments produced results that were indeed positive, but only weakly so. Finally, William Braud, a modern experimenter, concluded that: “the testing method used in these studies was not the most appropriate one.” After all, the sensation of being stared at does not register at the level of awareness, but in the form of various bodily sensations, such as skin conductance and the prickling of neck hairs as they stand erect.

It was this line of reasoning that persuaded Braud to turn his attention to effects of staring on the sympathetic nervous system, as measured by the galvanic skin response. He and his co-workers found the effect to be a fairly robust one, where the subjects responded correctly 59% of the time, (odds against chance were better than 100 to 1).

In a recent study, Marilyn Schlitz and Stephen LaBerge continued the work of Braud, adding a few refinements. A closed-circuit television device was utilized, in which the video camera was focused upon a volunteer, (called the Observee), while in another room a person called the Observer would, from time to time, stare at the image of the distant Observee, displayed on a color monitor. In this way it was possible to avoid any sensory contact between the Observer and the Observee. Throughout the course of the experiment the Observee’s galvanic skin responses were monitored. An automated and computerized system was programmed to record and average the physiological responses of the Observee during the sampling periods. The galvanic skin responses of the Observee during the periods of remote observation were then compared with those obtained during control periods—that is, times when no observation was taking place. The result? Significantly more galvanic activity was observed during periods of remote observation. In fact, the odds against chance for the study were 2000 to one.

A meta-analysis by Radin over all ‘staring’ experiments, conscious and unconscious, (including the negative result obtained by Coover in 1913), shows that subjects knew that they were being stared at 63% of the time, (as opposed to a 50% rate as predicted by ‘chance.’

Schlitz and LaBerge were also able to identify a gender effect. As one might expect, opposite-sex pairs showed a more pronounced effect than same-sex pairs; the odds against chance for this particular effect were more than 100 to one.

We have been looking at three experiments that were constructed to show the existence of telepathy. For our next adventure we shall investigate clairvoyance.

[2] Clairvoyance

In the 1920’s Sir Arthur Conan Doyle, creator of Sherlock Holmes, made the rounds in the U.S., lecturing to enthusiastic audiences on a subject dear to his heart: spiritualism. (Disclosure: I have read some of Doyle’s spiritualist stuff. I thought he was amazingly gullible, and must have been a perfect target for swindlers). In one of Doyle’s audiences sat a young man named Joseph B. Rhine, who received such a poor impression of Doyle, that he resolved to adopt a strict scientific protocol, and to investigate the subject of Psi, (then called ESP), himself. How was he able to do this? He was Professor of Psychology at Duke University, and persisted in his investigations for a period of thirty years.
His method involved having his subjects guess the symbols printed on distant cards, called Zener cards. Each one of these cards carries a symbol. The symbols include: a circle, a square, wavy lines, a star or a cross. A deck of ‘ESP cards’ comprises five sets of Zener cards. Thus, on a basis of pure chance, the odds of selecting the correct Zener card are one in five, or 20%.

The technique employed by Rhine required someone to look at the Zener cards while someone else, who can’t see the cards, (the Subject), has to guess at the nature of the symbol. The technical name for the procedure is: ‘forced choice,’ because the Subject doesn’t get to choose the target.

Over five years’ time during the 1930’s, Rhine performed 309 forced choice experiments, with consistently positive results, using a technique that also required precognition. The odds against chance? Ten million billion billion to one!

One of Rhine’s subjects was a young man named Hubert Pearce, who claimed to have inherited the psychic gift from his mother. In a total of 1850 individual trials, Pearce obtained 558 hits. This is associated with odds against chance of a billion billion billion to one! You would think that results of this kind would tend to settle the argument, wouldn’t you?

**Distant Viewing**

We have learned another thing about forced-choice Zener card experiments. Over time the subject’s performance tends to deteriorate. Why? Because staring at all those symbols is an *infernally boring* ordeal! So next we come to a kind of clairvoyance experiment that is dear to my heart!

In June of the year 1972, Hal Puthoff, a laser physicist at Stanford Research Institute, which was at that time a think-tank in Palo Alto, found himself acting as host to Ingo Swann, a New York artist, one of the country’s leading psychics, (and a very colorful character). Puthoff tells the following story:

“Prior to Swann’s visit I had arranged for access to a well-shielded magnetometer used in a quark-detection experiment in the Physics Department at Stanford University. During our visit to this laboratory, sprung as a surprise to Swann, he appeared to perturb the operation of the magnetometer, which was located in a vault below the floor of the building and shielded by μ-metal shielding, an aluminum container, copper shielding, and a superconducting shield. As if to add insult to injury, he then went on to ‘remote view’ the interior of the apparatus, rendering by drawing a reasonable facsimile of its rather complex (and heretofore unpublished) construction. It was this latter feat that impressed me even more than the former, as it also eventually did representatives of the intelligence community.”

Puthoff circulated a report of his encounter with Swann among his scientific colleagues, ultimately publishing it as part of a conference proceedings.

A few weeks later a pair of visitors showed up at SRI, a copy of Puthoff’s report in hand. They were from the CIA. It turned out that the Agency was aware that research in remote viewing was being carried out in the Soviet Union—a fact that placed the intelligence community in a dilemma. On the one hand they did not want to be at a disadvantage vis-à-vis the USSR, but on the other hand, for political reasons they didn’t want their interest in a problematic subject such as Psi to become widely known in
this country. What they had been looking for was a nice, quiet, out-of-the-way laboratory where the Agency could indulge its curiosity in a manner that would remain undetected.

When asked by the agents if they might be given a demonstration of Swann’s psychic powers, Puthoff assented, and arrangements were made. The visitors returned with boxes, in which they had concealed various objects, and Swann was asked to describe their various contents. In one test he said: “I see something small, brown and irregular, sort of like a leaf or something that resembles it, except that it is very much alive, like it’s even moving.” The target turned out to be a small, live moth.

This, and similar responses, seemed to convince the agents; and in a short while the CIA had funded a pilot study, in which Puthoff was joined by Russell Targ, a fellow laser physicist. Targ became “the psychic travel agent” for the group. Therefore the most interesting stories are his.

The first remote viewing experiments were performed using local targets, and in the course of this work Targ and Puthoff met Pat Price, former Police Commissioner of Burbank, California, and a natural psychic virtuoso. On one memorable occasion Puthoff, accompanied by the laboratory director, paid a secret visit to the swimming pool complex at Rinconada Park, Palo Alto. Meanwhile Price was sitting with Russell Targ in an electrically shielded cage at the SRI Radio Physics Building. Neither man was aware of the destination of Puthoff and his companion. In Targ’s words:

“…I told Price the travelers had probably reached their destination. He polished his gold, wire-rimmed glasses on a white linen handkerchief, leaned back in the chair and closed his eyes. On this particular day Price said that he saw a circular pool, about a hundred feet in diameter. (It was actually one hundred and ten feet in diameter). He also said he saw a rectangular pool, about 60 by 80 feet on a side. (This pool happens to be 75 feet by 100 feet). However, this illustration also shows one of the problems associated with remote viewing. Having described the target site with great accuracy, as yet unknown to us, Price told me that he thought the target seemed to be a water purification plant. He then went on to create some non-existent water storage tanks in the picture, and put rotating machinery in the pools.”

What was the cause of this apparent lapse on the part of Price? The answer did not become clear until arrival in 1995 (on Targ’s doorstep) of the Annual Report of the City of Palo Alto, celebrating its centennial year. The Report contained the following sentence: “In 1913 a new municipal water works was built on the site of the present Rinconada Park.”

The Report contained a photograph of the water tanks as they had been in 1913, and they are shown to have been exactly where Price had drawn them.

After a number of initial successes with local targets, the inevitable question arose: how to adapt the method so that it would be possible to expose targets behind the Iron Curtain to Remote Viewing? With that in mind it was felt that any further local viewing would be a waste of time. At this point Ingo Swann suggested giving the Viewer the coordinates of latitude and longitude. It was an idea that seemed far-fetched at the time, but it became standard operating procedure.

Other exploits of the Remote Viewers of the late Cold War are amply worth telling, but there is insufficient space here to do them justice. At the end of this chapter you will find a brief bibliography of books on these subjects, written by people I have met, and whose work I admire.
In the course of studying the Quantum Theory we have already seen that there is a certain elfish quality to what we call space and time. Until an observation collapses the wave function, space and time lack the drab mechanistic properties that they seem to have after the observation has taken place. In fact the classical view of space and time needs to go back ‘into the shop for a rebuild’, (just as soon as we can find the ‘parts manual.’) We learned this when we studied the Quantum Theory.

If we review cases of Remote Viewing, where the target was to be visited on a certain day, it often turned out that the Viewer picked the correct target before the Visitor actually reached it. So, we should not be surprised when cases of precognition occur. It’s in the DNA of Mother Nature.

We have already seen Pat Price’s interpretation of his remote viewing of Rinconada Park. That was a clear-cut case of retrocognition, for he was ‘seeing’ a water treatment plant that hadn’t existed in decades.

**Another example:** At Princeton University’s PEAR Lab there was a program called: Precognitive Remote Viewing (PRP). In one of their trials, the Viewer and the Visitor were located some 2200 miles from each other. Approximately 45 minutes before the Visitor randomly selected a target, the Viewer came up with a description that including the following phrases: “…inside a large bowl”… “…some smooth man-made materials like concrete….” Where was the Visitor going? To Kitt Peak, Arizona, in the bowl of a large, parabolic radio telescope. Bullseye! There were 334 PRP trials conducted between 1978 and 1987, and the odds against chance were 100 billion to one.

It is more instructive, I think, to look at the results of laboratory trials, and not trials of precognition, but rather trials of what we call presentiment. What is the difference? To pre-cognize implies having a conscious visualization of an event occurring in the future. A presentiment is a feeling, of which we may not be consciously aware, but whose presence manifests itself in the form of sweating, (galvanic skin response), and reduced blood flow to the extremities. It is rather presentiment that lends itself to measurement in a laboratory.

The design of this type of experiment, (largely a creation of Dean Radin’s), can be summarized in the following way: Two electrodes are fastened to the subject’s left palm, before he/she is seated comfortably in a chair, facing a screen, upon which two different types of photographs will appear. One type of photograph depicts a scene that is peaceful or pleasant; the other depicts an emotional scene—one whose content is either violent or sexual. As you might expect, if we plot skin conductance vs. time, the graphs show a much larger increase in skin conductance in the case where the photograph contains violent or sexual themes. But if we look carefully, we will notice that the skin conductance starts to depart from ‘normal’ as many as three seconds before the shocking photograph actually appears. (See Fig 14-2 below)
Radin goes on to tell of a bright student in Texas who invented an equivalent experiment, using earthworms as subjects. It was apparently successful! The animal’s premonition was shown to commence one second before the stimulus. This brings us back to John von Neumann’s tracing of the chain of events that make the collapse of the wave function. You may remember that he believed that it is human consciousness that collapses the wave function. That idea did sound fairly bizarre. After all, what is so special about humans? Where there is life there has to be consciousness. Although I can’t prove it, I wouldn’t be at all surprised to learn that not only is the universe conscious, but that the universe itself is consciousness.

\[4\] Psychokinesis

We have arrived at the last of the major categories of PSI: psychokinesis. It is also the most difficult phenomenon to produce, because it requires utilizing consciousness to perform mechanical work. We shall divide our discussion into two parts.

[1] Psychokinesis in Living Systems

During the time of the Soviet Union there were fascinating experiments carried out by Leonid Vasiliev, in which ‘Senders’ could apparently influence ‘Receivers’ located more than 1000 miles away. Also, a certain amount of research has been done in Europe and America to evaluate the efficacy of prayer. But in the latter case the results are inconsistent, and therefore inconclusive. Humans are complicated! Therefore I shall limit myself to a brief discussion of three experiments more fully described by Diane Hennacy Powell in her book: The ESP Enigma.
In the first study, paramecia, (single-celled organisms) are examined in the cross hairs of a microscope; which divide the visual field into quadrants. The experimenter concentrated on influencing the paramecia to move into one specified quadrant, a feat which they accomplished a statistically significant portion of the time. In a second study, randomly selected college students were able to increase or decrease the rate of bacterial growth by focusing their intentions upon them. In the third experiment, thirty-two subjects had a sample of their blood cells removed and placed in twenty tubes containing a dilute salt solution, which produces osmotic pressure, forcing salt into the cells until they burst. The subjects were asked to protect their cells psychically in ten of the tubes, and to let the cells fend for themselves in the other ten tubes. The difference between the protected cells and the control cells was positive in nine out of the thirty-two cases, and statistically quite significant. To have such uncomplicated subjects as paramecia, bacteria and blood cells, and to obtain some positive results is quite gratifying. The results of these experiments may shed some light on why some gardeners have a ‘green thumb.’

[II] Psychokinesis in Non-living Systems

First let’s talk about a kind of system that people have been trying to influence since deepest antiquity: dice. (They were originally bones!)

In the year 1989 Dean Radin and Diane Ferrari performed a meta-analysis to evaluate the combined evidence for psychokinetic effects (PK) in dice experiments. During the half-century between 1935 and 1987 some 2,500 people have attempted to exert influence over 2.6 million dice throws in 148 different experiments. The number of dice tossed in one throw ranged from one to 96. The odds against chance, (brace yourselves), were \(10^{96}\) to one! The effect on an individual throw was a small one, but the total number of throws was a huge one, (and that is what counts)! Radin’s discussion of this topic is much more complete, and covers the sort of details that might capture the attention of a skeptic. I give you here the reference: “Entangled Minds,” by Dean Radin, (Paraview Pocket Books, 2006).

The Random Number Generator (RNG)

This device essentially takes electronic ‘noise’ and fashions it into a series of electronic “spikes,” one volt high. These spikes are used to interrupt a crystal-controlled clock that is counting at, say: 10MHz. If the random spike interrupts the clock between successive ‘ticks,’ the RNG registers a binary output of 0. If the spike interrupts a “tick,” the RNG registers a binary output of 1. Thus, asking an operator to affect the output of an RNG is analogous to asking him/her to affect the outcome of a coin toss.

There are two differences between trying to affect the outcome of tossing coins and trying to affect the output of an RNG: (1) The output of the RNG involves a much, much smaller quantity of energy than that which is required to perturb the motion of a coin: (2) The RNG is producing 1000 bits (electronic coin tosses) per second. This is an improvement over tossing coins, since small effects require mountains of data.

In 1979, at Princeton University, Robert Jahn, then Dean of the School of Engineering, established the Princeton Engineering Anomalies Research Laboratory. Part of the Laboratory’s effort was, under the direction of Brenda Dunne, to create a highly successful ‘distant viewing’ program. But the bulk of the effort was devoted to the RNG program. The operators were unscreened volunteers; no psychic talent was required. During the experiment some volunteers ate their lunches, others meditated, and at least one was reported to have performed headstands.
Roger Nelson and Dean Radin have created a meta-analysis of all RNG studies, at Princeton and elsewhere, to determine the size of the overall experimental effect, which was about 51%, where a 50% result equals what we would expect from chance. You should note that this is about the same result that was obtained from throwing dice. What were the odds against chance? About 35 trillion to one!

Disclosure: For a couple of days I was one of the operators.

The RNG Escapes From the Laboratory!

It was Roger Nelson who had the necessary stroke of genius. Remember, the output of the RNG is a random array of 0’s and 1’s; and that randomness is the exact antithesis of order, so that we, as operators, focusing our attention on all that randomness, are trying to impose order upon it. What would happen, he asked, if many people with concentrated attention were gathered together: would this affect the behavior of the RNG? This led immediately to the next question: suppose that some single event were to grab the attention of hundreds of millions throughout the world. How would the RNG behave in that case?

It was in this way that Roger Nelson created the Global Consciousness Project: GCP.

The goal is to place a network of RNGs throughout the world. As Dean Radin expresses it, GCP would be like a network of buoys floating on the ocean, and transporting the cumulative sound of their ringing to a central receiving station. An event that captures the attention of hundreds of millions of people will produce a proportionately loud ring. On page 203 of Radin’s book: ‘Entangled Minds’ we find a graph of RNG readings for a period from the 15th of June to the 15th of September of the year 2001. And there is one reading that dominates all the others: that for September 11th. It was The Bell, tolling for all those who died that day, and probably for those millions who have died, and will have died in its aftermath. Furthermore, (although you may not realize it yet), it was tolling for the passing of the Democratic Republic of The United States of America. For by today all the speeches and elections have become: “a tale told by an idiot, full of sound and fury, signifying nothing.”

What is ‘Psychic Ability’?

In a way, it is akin to musical ability--to an extent it lies latent in most of us, and can be developed through coaching. Some of us have ‘perfect pitch,’ others are tone deaf. Some people at one end of the psychic spectrum are ‘naturals,’ while at the other end there are people who show almost no talent at all. I would classify myself as being closer to the latter end of the spectrum: a psychic ‘klutz.’

A decade ago I attended a weekend seminar at The Institute Of Noetic Sciences, at their campus at the north end of Marin County. Upon entering a small auditorium someone handed me a sealed envelope, to be placed in the breast pocket of my shirt. Frankly, I didn’t expect anything to happen, but I decided to ‘go through the motions’ like a good sport. Following instructions, I closed my eyes. I was amazed to see what seemed to be a kind of staircase, descending from left to right. There were thin, evenly spaced banister spokes. A voice in the room asked: “What color do you see?” I seemed to see a pale yellow. Hands shaking, I made a drawing of what I saw, and then opened the envelope, extracting a Polaroid photo. The scene was of a fairly steep hillside. Silhouetted against the sky was an evenly spaced line of straight, leafless, spindly trees, exactly like those banister spokes, illuminated by the wan yellow light of a winter sun. Although I had previously strongly suspected that Psi phenomena were real, it was no longer to be a question of mere belief. I had retained a certain skepticism. But after that moment I had seen it, and verified it, and now I know! They are real!
**A Final Word of Thanks**

We learn things that revolutionize our way of thinking. These mark important mileposts in our lives. One of these things was the Aspect Experiment. Before that time it was still respectable to think of the world as having an existence independent of observation (interaction). Now we can think of the world as being a series of events. I am grateful to these scientists.

Before the wonderful people at IONS gave me that envelope with the Polaroid picture, I couldn’t say with certainty that Psi phenomena were real. I am profoundly grateful to Dean Radin, to Russell Targ and the others. They have reenchanted the world for me, and I hope that some of the enchantment rubs off on you!

**A Reading List For Chapter Fourteen:**

**Dean Radin:**  
*The Conscious Universe*  
*Entangled Minds*  
*Supernormal*

**Russell Targ:**  
*Limitless Mind*  
*The Reality of ESP*

**Diane Hennacy Powell:**  
*The ESP Enigma*
CHAPTER FIFTEEN

I would like to start this chapter with a summation of the main topics that I have attempted to cover in this book,

First off: *Is the Universe Conscious?*

As before, I must reply with two more questions: “Do you consider yourself to be conscious?” And: “Do you think of yourself as being a part of the universe?” From this point on, I guess that we can answer the original question in the affirmative.

What, then, is consciousness? This is called ‘The Hard Question.’ One definition, according to Webster’s Collegiate, is: “the quality or state of being aware, esp. of something within oneself.” Another definition, derived from that one, is: “self aware.” This latter definition describes our own situation; and therefore it describes the universe, of which we are a part. But there remains a question: “Is the universe conscious merely because we have taken up residence within it? I suspect strongly that there is much more to it, but that the final truth is so discordant with rest of our waking experience, that we can’t achieve the one necessary goal for making a successful definition: expressing something distant from our experience in terms of something more familiar, more proximate. It’s like making a road to connect an outpost in the jungle to your capital city—when you don’t *have* a capital city. But the experience of living in a conscious environment was so well described by Stanislav Lem in his novel (and film) *Solaris.*

*From the shamanic point of view,*

*Everything that is,*

*Is alive.*

Michael Harner

Von Neumann felt that the wave function was collapsed by the ‘consciousness’ of the human observer. Can we extend this property: consciousness, to other members of the animal kingdom? It certainly seems so. A clever experiment has been performed, indicating that at least one dog knew when his owner was coming home, at the time when the owner was just leaving her office. Once I heard an anthropologist at U.C. Berkeley describe how the Mayas capture fresh water snails by means of chanting to them. These examples cause me to remain ‘open’ to the idea that consciousness is not localized.

How about plants? Is there any evidence that plants communicate with one another? Some experimenters claim that this may be indeed the case. For example, positive results have been obtained by praying for the growth of seedlings. But there isn’t yet, in this latter case, a sizeable body of convincing experimental data. The more data there are, the more confidence we will have. A good skeptic can withhold judgment for a long time, while he or she examines the point at issue.

But there is yet one more thing to consider. It is entirely possible that consciousness is *not* localized—that it is a kind of *field,* one that is actually the basis for the universe. Thus considered, consciousness is not a product of the universe, but rather the other way ’round. *It is the universe that is a product of consciousness!* The universe, to this way of thinking, is actually a type of *information.* Can we say more about this? Yes!
First, there have been quantum mechanical experiments that are hard to interpret in any other way, than in terms of consciousness. The delayed choice experiment is certainly one of them. In his interesting book: ‘Biocentrism,’ Robert Lanza describes an experiment that is called the ‘quantum eraser.’ (He doesn’t use that title, but you can read about the quantum eraser in Wikipedia). For me, it is impossible for one to explain this experiment without giving consciousness a starring role.

Second, I have been extremely careful to include references to statistical data when talking about Psi experiments. Before having had my own clairvoyance experience, these references were all that I had at the times when I discussed these experiments in class. If you want to verify any of the statistical data, you need to look up the references cited in the appendices of the books that I listed at the end of Chapter Fourteen.

Third, (and last), there is Dean Radin’s ongoing experiment to see if it is possible to destroy the interference pattern produced by the two-slit experiment, using of human intention. So far, the results are promising. You can read in detail about this in Radin’s excellent book: ‘Supernormal,’ and you should do so!

In the matter of the universality of consciousness, John Archibald Wheeler, (Richard Feynman’s own professor), described the idea succinctly: “It from bit,” where the word: “bit” comes to us from Information Theory; it is the difference between a 0 and a 1, in binary notation. What Wheeler meant, is that we can arrive at a better understanding of the world if we think of phenomena in terms of information. The reasoning is straightforward: We don’t detect objects; we detect events. A registered event gets a score of +1; A non-event gets a score of zero. This is the very stuff of information.

But, is there not evidence suggesting that consciousness is merely a product of human brain metabolism, in the same way that urine is a product of kidney function? This is a question of interpretation. If we start out with the assumption that the arrows of causality all point to downward to ‘stuff,’ then we merely beg the question; the brain will be crammed into the a priori role of a ‘broadcasting station’ of consciousness. The alternative view is that we are more nearly like receivers of consciousness, because there is no evidence that any ‘consciousness’signal is being transmitted locally, (like a phone call, say). There is a way of deciding which interpretation to adopt: We simply look at the laboratory data for all the Psi experiments that have been performed. They indicate strongly that We are all ‘as one,’ as Francis Bacon put it: ‘by a secret sympathy.’ So, think of the brain as a television set, if that metaphor is of use to you.

About Myth

And thus the native hue of resolution is sicklied o’er
With the pale cast of thought;
And enterprises of great pith and moment,
With this regard, their currents turn awry,
And lose the name of action.

Hamlet, Act III, Scene I

It is Myth that forms our thoughts and directs our actions. In my view, a very large portion of the book is about Myth. Ever since I was a little child, I was baffled by the mental contortions that adults used to arrive at conclusions that contradicted their premises. With time I came to realize that this type of behavior is not at all an indication of ‘weakness of intellect;’ it is simply how we behave. (Indeed, I
caught one of the most brilliant men I ever knew, quoting Rush Limbaugh as if he were citing Holy Writ (which would have been bad enough in itself). If you look at Galileo and Newton, whose ideas evolved into Holy Writ for the likes of Laplace, Kelvin, and even Einstein, you will appreciate what I mean by *Mythology*. And as with any creation myth, it gave them the motivation to pull their shoes on in the morning.

And so here is a myth, one that has seduced the minds of untold thousands:

**Einstein:** “The belief in an external world independent of the perceiving subject, is the basis of all natural science.”

In the chapters on the quantum theory we have seen how this notion, however bravely and brilliantly set down by one of the most wonderful minds of his time, has been falsified by an ingenious experiment, one which was to bury his notion under an avalanche of other experiments. One would like to believe that every scientist would have had such a “conversion experience,” like the one some kids heard in Sunday School—the story of Paul on the way to Damascus.

But it doesn’t really work that way. It isn’t the way people *behave*.

The first scientist to test Bell’s inequality, (i.e, to show that Einstein’s “hidden variables” do not exist), John Clauser, had been a graduate student at Columbia University. According to Dean Radin, historian Olival Freire remarked that:

Some of the physicists who decided not to hire Clauser were influenced by the prejudice that hidden variables were not “real physics.” His former adviser, P. Thaddeus, wrote letters warning people not to hire Clauser to do experiments on hidden variables in quantum mechanics as it was “junk science,” a view shared by other potential employers.

And in the case of Psi phenomena, it is even truer that prejudice is the rule, rather than the exception. When it comes to blind, stupid intolerance the Church does not have the market cornered.

Most of you have heard of Carl Sagan, the astronomer and TV star. In his younger days his attitude toward Psi phenomena was one of doctrinal disbelief: *cultism*. But one day he chanced to meet Daryl Bem, whom I mentioned in the previous chapter, a man who respects only experimental data. (Disclosure: I have been a subject in one of his experiments.) You will recall that Charles Honorton persuaded him to collaborate on a ganzfeld experiment. He is a true skeptic; the data convinced him. The odds against chance for that particular experiment were 45,000 to one. You may recall that a meta-analysis of *all* ganzfeld experiments show odds against chance of more than $10^{15}$ to one. So, as a scientist, Bem really had no choice. And, to his credit, neither did Sagan. In his last book, written in 1995, Sagan wrote:

**At the time of writing there are three claims in the ESP field which, in my opinion, deserve serious study:** (1) that by thought alone humans can (barely) affect random number generators in computers; (2) that people under mild sensory deprivation can receive thoughts or images “projected” at them; and (3) that young children sometimes report the details of a previous life, which upon checking turn out to be accurate and which they could not have known about in any other way than reincarnation.
By the way, what is a skeptic? The word comes from the Greek: skeptikos = one who is thoughtful. Skeptesthai = to look or consider. We get words like ‘microscope’ and ‘telescope’ and we ‘scope things out.’ How about the people who publish The Skeptical Enquirer, are they skeptics? No. They are just being neurotic!

It is my hope that these, the major subjects of this book, have been treated in such a manner as to arouse your interest. I believe that they have been marginalized in western culture, which has been preoccupied with, and characterized by materialistic concerns. It is the very self-congratulatory mind-set that accompanies modernity that most requires a skeptical treatment. What are needed are first, a clinical detachment from the modernity’s conceits, and a warm compassion for those who are being broken on its wheel.

**The really great question is: Who are we?**

This requires a kind of exploratory expedition into pre-history, the time before we got caught up in the vortex of the three ‘abrahamic’ religions: Judaism, Christianity and Islam. In particular, what were the beliefs that people held in common before the advent of ‘civilization?’

My first reference is to “The Inner Reaches of Outer Space,” a kind of summary of the ideas of the late Joseph Campbell, who starts with the sentence:

> Reviewing with unprejudiced eye the religious traditions of mankind, one becomes very soon aware of certain mythic motives that are common to all, though differently understood and developed in the differing traditions: for example, of a life beyond death, or of malevolent and protective spirits.

According to Campbell, Adolf Bastian, the leading ethnologist of the nineteenth century, had a term for these recurrent themes. He called them ‘elementary ideas,’ because he found them everywhere in his travels.

My second reference is to “Shamanism,” by the scholar Mircea Eliade, who made a comprehensive study, discovering that shamanism forms a kind of ‘bed rock’ to all world cultures. It is practiced on all inhabited continents by indigenous peoples. It’s what we were all doing before the missionaries showed up. A present-day disciple of Eliade is the scholar Michael Harner, who sums up shamanism in the following way:

> Shamanism is universally characterized by an intentional change in consciousness to engage in intentional two-way interaction with spirits.

Essential to shamanism is the concept of *non-ordinary reality*. One reaches non-ordinary reality by many routes, principally by one of the forms of ‘sonic driving,’ the principal mode of which is shamanic drumming. According to Harner, one uses a steady, monotonous beat of 205-220 times a minute. This beat, 3.4 – 3.6 beats per second, corresponds to theta EEG frequencies: conducive to the production of altered states of consciousness. Other simple routes to non-ordinary reality include musical bows,
Tibetan bowls, gongs and strobe lights—all of them acting in a manner similar to principle of the drum. Polishing crystals with emery cloth will do it, and so will tying macramé knots.

For many shamans, non-ordinary reality consists of three zones: the upper world, the middle world, and the lower world. For the shaman, the drum is his/her ‘horse,’ the vehicle that transports him/her, either to ‘lower world’ to meet a ‘power animal,’ or to the ‘upper world’ to consult with a spirit guide, or sometimes to obtain the help of ‘middle world’ spirits. According to Harner, by this time thousands of people here in the Western Hemisphere, in Europe and in Asia have participated in his workshops. Harner and his team have even made contact with shamans in Mongolia and Tuva.

And, of course, there is always psilocybin. Harner doesn’t recommend its use, probably because its action is “out of your control.” The late, great apostle of psychedelics, Terrence McKenna, compared the effect of psilocybin to a tsunami: “…from Vancouver to Tijuana, and I’ve just crawled under the desk!” In the case of drumming, the route to non-ordinary reality often involves a lot of hard work. With psilocybin however, the matter is usually taken out of one’s hands. Recently, in a cave in Western Spain, a beautiful piece of 11,000 year-old art has been found on one of the walls: mushrooms, identified by a local mycologist as psychedelic. In warning, I need to add that there are other mushrooms, ones that bear a similarity to the various ones containing of psilocybin—except that instead, they will put you on an agonizing trip to the cemetery. A thorough familiarity with the discipline of mycology is absolutely essential for the hunter of ‘magic mushrooms.’

I confess that, whatever other spirits may exist in the world, it is shamanism that raises my own little spirit. If you ask for a simple reason, I will be glad to give you a complex answer—actually it is in the form of a story. When I was a child, the world was, for me, a magical place. But it was understood at the time, that if you wanted to be an: ‘educated person,’ you had to read the great authors, and learn how to appreciate great music. My favorite composer was Jean Sibelius (1865-1957), the National Composer of Finland. A great deal of his music was inspired by: the Kalevala: the Finnish National Epic. Part of this epic tells of the adventures of Vainamoinen, who was attempting to win the daughter of Pohjola, a woman who was too much young for him. Her method of defense was to set a number of impossible tasks for him to perform; and in the process he cut himself with his own axe. Worse yet, he couldn’t stop the bleeding. So he sought out a shaman, who recited a spell, which ‘did the trick.’ He left the shaman’s ‘office,’ a healthier, and a wiser man. The thought that you might be able to affect someone’s body by reciting a spell had a magical effect on me; and as the years went by, I never, never forgot that story. The music even plays in my mind when I write these words.

The years passed, and I had to play many roles, like we all must do, on the way to becoming adults—(some of us never stop). In the process I fell under the depressing spell of mechanistic materialism. But one day when I was a graduate student, while threading my way through Detroit traffic to my laboratory, I happened to hear a lecture by a professor at the University of Michigan, who told about meeting a woman at a bus stop in Northern Finland, (she turned out to be a former student of his). The woman told him that her father was a ‘witch doctor,’ who could control the flow of blood in any vessel in his body! What a thrill that was! When you read further in this chapter you will learn that this is also one of the recognized attainments of an accomplished yogi.

To reach Michael Harner’s Foundation For Shamanic Studies, go to his e-mail address: info@shamanism.org If you wish to read more about this subject, there are two very fine books by Michael Harner:
The Way of the Shaman: (This book is now in a second edition, and my copy is a first edition, (1982), so I can’t give you the name of the present publisher). But you can easily obtain a copy at the above e-mail address. Harner’s most recent book is: Cave and Cosmos, Northern Atlantic Books, 2013, Berkeley, CA, 94712

The Spirit World

The belief in spirits is a very old one. From ancient England to Peru, to present-day New Guinea, this belief has been ubiquitous. You probably know that the English countryside is dotted with ‘standing stones,’ menhirs. Nearly a hundred years ago it was discovered that many of them are arranged along straight lines, (ley-lines), over a distance of many miles. Similar arrangements existed in the Netherlands and in Germany: called doodwegen in the first case, Todwegen in the second. These names appear to shed light on the mystery, for the following reason: It was believed that when someone dies violently or unexpectedly, his/her spirit is confused and loiters in the vicinity of the corpse. Thus, those who bear the corpse to the cemetery must take care not to go around sharp corners, or the spirit will get ‘lost,’ and wander back to the home it had in life, thus creating a real problem in the village. When we say: “Rest in peace,” the phrase apparently has its origin in pre-Christian times, and seems to carry a different meaning from that which you were taught in the Sunday Schools. See: The Tibetan Book of the Dead, translated by Robert Thurman, and The Tibetan Book of Living and Dying, by Sogyal Rinpoche. The Tibetan monks are masters of this subject!

There is an interesting, (and recently published) book: Whisperers, The Secret History of the Spirit World, by James H. Brennan. His argument is that, throughout history, (including very recent times), many influential persons have been influenced by what they believed to be instructions from spirits. Throughout most of the book Brennan is careful to avoid taking a position as to the veridicality of these spirit communications; he simply states what it was that these individuals claimed to be their source of advice. In short, he is skeptical, or at least very careful. He toys initially with a theory, propounded by the late Julian Jaynes, Professor of Psychology at Princeton University, one that proposes that, until historical times, the two hemispheres of the human brain acted independently of each other. Thus the right temporal lobe would, on occasion, issue instructions to the left hemisphere in the form of commands, ones that the unwitting individual, (the owner of the brain), misinterpreted as having come from the gods. This idea is not as crazy as it looks, even if it is, on the face of it, naively reductionist. If you will only scan a copy of Homer’s Iliad, you will notice that the true protagonists are the gods of the Greek pantheon. They create the script of the story, while the humans are merely actors in the play. But toward the end of his book, Brennan edges away from Jaynes, and comes down on the side of Carl Jung, who was of the opinion that, underlying our mental experiences is an ancient non-local substrate that he called the “collective unconscious,” containing a kind of collective ‘memory’ of the human race. It is an interesting book, and Brennan writes well. But neither he nor I can define exactly what a spirit is. It is merely a word. Worse yet, I cannot produce any experimental results, fortified with gigabytes of meta-analysis. Thus a certain degree of open-minded skepticism is order—but not a great deal of it.

The True Significance of Yoga

Over the past fifty years or so, the practice of yoga has sunk a deep taproot into American culture. Most of us have practiced yoga at one time or another—usually Hatha (physical) Yoga, which is a deeply relaxing form of calisthenics), made up of an impressive repertory of poses, (asanas). There have been moments, in yoga class, when we even arrive at a slightly altered state of consciousness, but this moment of euphoria is transitory, and easy to ignore—especially since, in this country the emphasis is
more on acquiring ‘the body beautiful.’ Moreover, since we have learned to associate yoga with India, we find it easy to think of it as peculiar to that country.

First, physical yoga is really only the ‘third path’ out of eight forms of controlled activity, the purpose of which is to induce within us a state of Samadhi (ecstasy). One of the pioneers in bringing physical yoga to the West was B.K.S. Iyengar. But even he stipulated that its purpose is to strengthen the body so that it can perform pranayama, that is: conscious-breathing techniques. These techniques lead us to meditation, and eventually through an altered state of consciousness, to Samadhi.

Second, we don’t know the source of yoga: where or when it originated. It may well have been the Vedic culture, (6500 BCE) which has been uncovered in the valley of the Indus River. But at present, no one can say with confidence what the actual origin of these people could be. In Indian archaeology, due to the extreme antiquity of the culture, as well as the materialist prejudices of Western scholars, all is not what it would seem to be in this game. In ancient India they showed no interest in writing history.

**Yoga and Psi: There is a Connection…**

To my knowledge, the most influential treatise on yoga is: Yoga Sutras of Patanjali, which was written around 150 CE. It comprises four sections, called paddas. The third of these: vibhuti pada, deals with what Patanjali calls siddhis: (‘attainments’). Among the siddhis we not only find gifts such as telepathy, clairvoyance, precognition and psychokinesis; we also find six siddhis dealing with mind-body control. So we should not be surprised to learn that a skilled yogi will claim to be able to control the flow of blood throughout his/her body.

You will find a very sensitive, comprehensive review of this topic in Chapter 7, of Dean Radin’s marvelous book: *Supernormal*.

One more little thing: What age can we assign to Indian civilization? The customary age given by scholars to the worldwide transition from hunting and gathering to farming has been set at 10,000 years BP. This assignment seems to agree tidily with what we see “on the ground” in Western Europe, where I have crawled around in a number of Paleolithic and Neolithic sites. But there are some exceptions. Near Madras there is a splendid temple to Shiva. But there also is a much older Shiva temple—off the coast, under water. What is clear to us today is that we live in an interglacial period. Therefore the engulfed temple must be very, very old. Lazy ‘Scholars’ have set the data of the beginning of the Vedic culture of India at 1500BCE. Good luck with that! At the far western corner of India is the province of Gujarat. Off the west end of Gujarat there is a city—one that drowned. Its name is Dwaraka, and you can access it in Google. And there is more—but for another time, perhaps. One thing seems certain: Vedic India is very, very old.
POSTSCRIPT

It’s hard to make predictions—especially about the future.
Niels Bohr

WHERE ARE WE GOING?
AND HOW DID WE GET INTO THIS HANDBASKET?

When I was a young man, there was always an unspoken assumption in America that the future was necessarily going to be better than the present. (But not any more!) In those heady times the ‘Journal of Record’ of the American Physical Society: *The Physical Review*, started appearing twice monthly; and over time, it multiplied and grew steadily thicker. Surely we felt that it was a harbinger of good things to come. But by the 1960s someone had already calculated that the number of physics journal articles was actually growing exponentially, (like the rabbit plague in Australia). This revelation brought about a slight chill, for we couldn’t avoid thinking of all those brooms in the story of The Sorcerer’s Apprentice, (with music by Paul Dukas, played by the Philadelphia Orchestra, conducted by Leopold Stokowski, with Mickey Mouse in the starring role). Some of us must have realized that the party was going to have to end some day. But most of us, myself included, stupidly saw the course of Science and Civilization as a monotonically ascending curve. Peak civilization? Fiddlesticks! The sky’s the limit, and the world’s our oyster! And what fools we were!

At that time the wealth of the United States was at its apogee, a fact that obscured one of the most fundamental laws of Science: *Somebody always has to pay the bills! And science always costs money.* These bills were growing exponentially, just like the number of pages of articles in the journals. What we didn’t realize until more recent times, was that a good deal of the growth of scientific discovery and of its laboratories in this country, was simply window dressing for the Cold War with the Soviet Union. Believe me, our ruling classes have never been consumed with a burning curiosity about the significance of Bell’s Theorem! What we in science had really been doing was to give them a sufficiency of weaponry to attempt to achieve a lasting hegemony over the whole world. What they really lusted after was: Empire. And they are fools, too!

In the year 1897 Queen Victoria celebrated her Diamond Jubilee, and for this occasion Rudyard Kipling wrote the well-known poem: *Recessional*. In the poem one finds a passage that mentions the fate of two ancient empires: those of Nineveh and Tyre. Kipling hoped fervently that this wouldn’t happen to England. These post 9/11 days certainly seem to be full of ‘Kipling moments,’ don’t they? This is a consideration that brings us inevitably to the subject of ‘political-economic astrophysics:’ Birth and Death.

At the beginning of its existence a star is almost exclusively composed of hydrogen nuclei, which are pulled by gravity toward the star’s center. As they fall inward, these nuclei collide with others of their kind; and if the collision is violent enough, the two hydrogen nuclei will coalesce to form a nucleus of ‘heavy hydrogen,’ (called: deuterium). This is the kind of process that produced the build-up of all the heavier elements, a process called nucleogenesis. Two deuterium nuclei will eventually combine to form a helium nucleus. As far as I know, just about every atom in the universe has started its career in this manner. But helium, the product of this process, 0.7% lighter than the four initial hydrogen atoms; and it is this difference in mass that produces enough energy to counteract the inward pull of gravity, stemming the flow of atoms toward the center of the star. (Note: Curiously, if the ‘0.7%’ were even slightly different from its observed value, we wouldn’t even exist. Remarkable!) But the life of the star
is one of continual struggle against the gravitational forces conspiring to produce its collapse. For most of its career, a star lives by burning hydrogen—using up its savings account and credit cards.

How long can this process go on? I give you this answer: *The lifetime of the star depends crucially on its mass.* A massive star will exert a stronger gravitational pull upon the hydrogen nuclei that constitute its fuel, thereby producing more collisions per unit time, and therefore liberating correspondingly more energy. Since its initial supply of hydrogen, though large, is still finite, the life of a giant star will be correspondingly brief—much briefer than that of a star of more modest proportions. This is a point that will prove to be a vital one when we compare the life of a star to that of a civilization.

As more and more helium is produced, correspondingly less hydrogen will remain; and so, inevitably, helium nuclei will start to collide with each other. However, the result of this union is a very strange one. The result of a collision between two helium nuclei is a very unstable isotope of beryllium, one with a very short lifetime. But if, while the two helium nuclei are still sticking together, a third helium nucleus happens to come along, the whole mess coalesces—into a nucleus of carbon! If *this improbable quirk of nature had not been available, there would be no life in the universe!* As the physicist Freeman Dyson, once expressed it: “The universe must have known that we were coming.”

As the burning of helium comes to constitute the dominant mode of metabolism for a star, a strange transformation occurs within its body. It ejects a part of its mass, which forms a vast, cool envelope, and in time it becomes what is called a Red Giant. The atoms in the envelope, (the 99%) no longer contribute to the star’s energy economy, and the real business of burning is now taking place in a small, white-hot region at the heart of the Red Giant, a region that is, in effect, a White Dwarf, (home of the 1%). There is an obvious analogy here to our own situation, right? The nuclei in the White Dwarf constitute a kind of celestial oligarchy.

With the passage of time this scenario continues to play itself out. The hungry star proceeds to “burn its way up the Periodic Table—until it reaches the element: iron. The star has by then reached its ‘tipping point.’ Past that point, every successive event of nucleogenesis requires more energy than it can deliver in return, making it impossible to stave off that implacable bill-collector: Gravity. The star has run out of fuel. Past this point various collapse scenarios present themselves. Small stars, (like our sun), merely become White Dwarves, and seem to subside ultimately into a kind of stellar ash. Larger stars, perhaps five times the size of the sun, will become supernovas, and collapse into neutron stars, a mere seven or eight miles in diameter; while the real giants will implode upon themselves, dragging with them the very fabric of space-time, as they sink out of the universe, becoming black holes.

As an aside, I can’t resist the temptation to mention that such a cataclysm, the one attending the death of a star—a supernova, will scatter a host of heavier nuclei across the star fields of space. These nuclei are gathered up in the gravitational field of other, younger stars, perhaps becoming incorporated into planets. And it is just these nuclei that will come to provide the atoms essential for life in the universe. It is from such monstrous events that arise the beauty and variety of life. We all know that the central atom of hemoglobin is iron, so a star must die bring blood into our bodies.

And now back to my story. In the Introduction to this book I likened civilizations to stars. After all, they are both kinds of heat engine, so they both require a steady diet of fuel in order to live. In the case of our own civilization, we have been feeding off of sunlight ever since one of our ancestors discovered fire.
Think about it! Plants require photosynthesis in order to live; they constitute distilled sunlight. Animals, including humans, subsist off of plants, or other animals. Thus we, too, live on a diet of sunlight. Coal, oil and natural gas are really ‘ancient sunlight,’ as author Thom Hartmann once pointed out; and the right to burn coal was given by royal permission to the freemen of Newcastle in about the year 1397CE. Out of this continuing raid on the Bank of Ancient Sunlight, as well as the from the pillage of the New World, that was born the wealth, (even the social optimism), of the past quarter-millennium. And of course there came the rise of the great empires, as well as the rise of Modern Civilization. It is interesting to note that in previous civilizations, whenever available energy became scarce, wealth and its concomitant political power became limited to a tiny fraction of the population, who proceeded to act as if it were theirs by Divine Right. It is even more disturbing to find that most of the time the great majority, the commoners, usually submitted meekly to this demeaning arrangement.

Joseph Tainter, Professor of Sustainability at Utah State University, has for decades been a student of civilizational collapse. In his book: *Drilling Down*, co-authored with Tadeusz Patzek, he offers valuable knowledge about the slow disintegration of the Roman Empire. It had reached its apogee by the year 235CE, and had achieved this condition by means of the subjugation of the other countries in Europe, North Africa and Asia Minor. It had acquired wealth and dominance by expropriating the wealth of other countries. Tainter expressed this astutely as “stolen sunlight.” By the middle of the third century, the empire had become overextended, and had very slowly begun to implode. From that point it ‘bought time’ by means of its common citizens into penury, thousands of them became hopelessly indebted. These unfortunate people were sold into slavery. (This is not a very strange notion; when we consider it in the context of the present-day student loans). In the United States today it is estimated that the 400 or so billionaires control an amount of wealth equal to the wealth possessed by that fraction of the population dwelling below the 50th percentile. This is not good news, is it? This would be especially true if you had, from childhood, been inculcated with our societal myth: that Western Civilization was the way of the future, and that the future will always be better. Let’s see what Aldous Huxley had to say about our country.

Huxley was a prophet for our times. He died on November 22nd 1963, and his book: *Brave New World Revisited* appeared in 1958. In its pages he had some wise advice to give:

> But the increasing pressure of numbers upon available resources is not the only force propelling us in the direction of totalitarianism. This blind biological enemy of freedom is allied with immensely powerful forces generated by the very advances in technology of which we are most proud. …

> But the Nature of Things is that nobody in this world ever gets anything for nothing. These amazing and admirable advances have had to be paid for—and each installment is higher than the last. Many historians, many sociologists and psychologists… point out, for example, that democracy can hardly be expected to flourish in societies where political and economic power is being progressively concentrated and centralized. But the progress of technology has led, and is still leading, to just such a concentration and centralization of power. …

> …a capitalist democracy, such as the United States,... is controlled by what Professor C. Wright Mills called the Power Elite. This Power Elite directly employs several millions of the country’s working force in its factories, offices and stores, controls many millions more by lending them the money to buy its products, and through its ownership of the media of mass communication, influences the thoughts,
the feelings and the actions of virtually everybody. To parody the words of Winston Churchill, never have so many been manipulated so much by so few. …

The best of constitutions and preventive laws will be powerless against the steadily increasing pressures of overpopulation and of the over-organization imposed by growing numbers and advancing technology. The constitutions will not be abrogated and the good laws will remain on the statute book; but these liberal forms will merely serve to mask and adorn a profoundly illiberal substance. Given unchecked overpopulation and over-organization, we may expect to see in the democratic countries a reversal of the process which transformed England into a democracy, while retaining all the outward forms of a monarchy. Under the relentless thrust of accelerating over-population and increasing over-organization, and by means of ever more effective methods of mind-manipulation, the democracies will change their nature; the quaint old forms—elections, parliaments, Supreme Courts and all the rest—will remain. The underlying substance will be a new kind of non-violent totalitarianism. All the traditional names, all the hallowed slogans will remain exactly what they were in the good old days.

Democracy and Freedom will be the theme of every broadcast and editorial—but democracy and freedom in a strictly Pickwickian sense. Meanwhile the ruling oligarchy and its highly trained elite of soldiers, policemen, thought-manufacturers and mind-manipulators will quietly run the show as they see fit. Thus it is a political axiom that power follows property. But it is now a historical fact that the means of production are fast becoming the monopolistic property of Big Business and Big Government. Therefore, if you believe in democracy, make arrangements to distribute property as widely as possible.

At this point you may be asking yourself: “Who was Aldous Huxley?” He was the grandson of Thomas Henry Huxley, Charles Darwin’s champion in the fight to gain acceptance for the Theory of Evolution. His brother Julian, as well as his half-brother Andrew, both won Nobel Prizes in biology. Aldous, as I recall, originally intended to follow in his father’s footsteps and become a physician, but the aftermath of an eye injury left him almost blind. His prophetic novel: Brave New World, which appeared in 1931, brought him lasting fame. The perceptiveness that he displayed in the above grim analysis of the fate of democratic government never ceases to leave me in a state of awe. Huxley wasn’t always right; but he was always brilliant. Further, he was a decent man, and revered for his kindness and compassion.

To return to my original narrative, the hydrogen-burning phase of America began to sputter out in the early 1970’s, and the White Dwarf phase (a kind of self-cannibalization), commenced in the 1980s. This seems to correspond to the state of the Roman Empire in the mid-third century, CE. In the United States more than 2,500,000 people are in the clutches of the so-called: ‘criminal justice’ system: (It depends on how you parse that phrase). Loans to college students have already surpassed a trillion dollars, and much of this gargantuan sum will be unredeemable. Thus, The System is broken! And there is very little prospect for a cure for this disease, because too many powerful people are making money from it.
And Now For That Perfect Storm, Brought to Us by Western Civilization…

There is no secret here. Western Civilization has been kept in existence by the burning of fossil fuels—Ancient Sunlight. The waste products of this enterprise are threatening to kill the planet whereon we live. Most of us are aware that temperature records are continually being broken. If we ceased burning carbon compounds tomorrow, temperatures are expected to go on climbing for decades—perhaps even centuries. But much, if not most, of the carbon dioxide that we are releasing is being absorbed by the oceans, thereby increasing their acidity, making them inhospitable to life. According to present estimates, the oceans are more acidic today than at any time in the past 300,000,000 years. The end product of this process is terrifying to contemplate. So I hope you won’t mind if I call this: The Worst Case Scenario, (in that it is to be avoided at absolutely any cost). Professor Michael T. Klare (fears that this is just what is going to happen. He is quite an expert; and you can find him on Google. If you read what he has written though, you’ll find that he doesn’t say much about the practicalities of drilling for ‘tight oil,’ by which I mean ‘fracking’ and scrounging for bitumen, (as they are doing in Alberta). So we need to look elsewhere. Fracking destroys vast amounts of potable water, and water is a scarce commodity on this planet. And there can be no life without it.

The Second Scenario is an extension of our previous excursion into the realm of astrophysics. Instead of hydrogen, (hard to find in burnable form), the fuel in question is Ancient Sunlight. In particular, I mean oil, because it is so easily transported, and it is the source of gasoline. What I want to talk about is the concept of peak conventional oil. This definition temporarily allows me to exclude talking about ‘tight oil.’

What can we conclude about the production of this stuff? My information comes from an article in Wikipedia. According to the IEA, (Int’l Energy Administration): Of 811 oil fields, their output is declining at an average of 6.7% per year. This implies that, in about 12 years, (the year 2024) the output will have fallen by one-half. Of the largest 48 fields, 33 of them are known to be in decline. Of course, (the good news), there is more drilling, and there are more minor discoveries going on continually, so that, for now, worldwide oil production is declining at only 4.1% per year. At that rate there will be half as oil as there is at present in the year 2031. So, for conventional oil, the peak occurred (probably) in 2005, (on Thanksgiving Day). It could have happened as late as 2007. But in any case, conventional oil is becoming, as they say: ‘history.’ To keep the lights burning in the homes of Western Civilization, it has been estimated that it will require the discovery of a new Saudi Arabia every 3-4 years. “good luck with that one.” Try prospecting on the moon!

So, then how about ‘tight oil”? After all, have we not heard from our politicians that the United States has enough ‘tight oil’ to qualify as the new Saudi Arabia? Not so fast! At present there are two major sources of ‘frackable’ oil in the ‘lower 48’: one in North Dakota, and the other in Southeast Texas. It was initially hoped that the United States would be able to wean itself off of its dependence of foreign oil by means of fracking, but the rosiest estimates for ‘tight oil’ predict a maximum output of 5 million bpd, (barrels per day). The U.S. presently imports an amount of oil equal to 9 million bpd. This, combined with its domestic production, adds up to 18 million bpd, for the total daily oil consumption. A retired oil executive recently delivered a lecture at University College London, and used the following amusing simile:

"We’re like a cage of lab rats that have eaten all the cornflakes and discovered that you can eat the cardboard packets too. Yes, we can, but... Tight oil may reach 5 or even 6
million b/d in the US, which will hugely help the US economy. Tight oil production in the US is likely to peak before 2020. There absolutely will not be enough tight oil production to replace the US' current 9 million b/d of imports."

There is an all-important ratio that is useful for us to understand the effect of peak oil on our future, and that of our descendants: It is: Energy Recovered Over Energy Invested, EROEI. If you require the energy in one barrel of oil in order to receive ten barrels, then The Ratio is equal to: 10. (Back in the 1940’s EROEI was usually equal to about 100, but those days are gone forever). In the case of fracking, The Ratio is less than five. What does this mean for the price at the gas pump? The Answer: very expensive oil (like a bottle of Cabernet Sauvignon). On the day when I wrote these words the price of a barrel of crude oil was about $102.50; it has been oscillating narrowly around $100 for quite a while now—but not forever. At the point when the price rises dramatically, the world economy will go ‘into the ditch’, and stay there. Thus ends the petroleum engineering part of my story.

In addition to the book by Tainter and Patzek, you should read The End of Growth by Richard Heinberg. You can find him on Google, also. It is Heinberg who looks clearly at our Perfect Storm from the standpoint of peak oil, and concludes that Growth must have a stop! Believe me, this will happen, no matter what we do!

When The Lights Go Out

It is very interesting to try to visualize what will become of us, once the price of a barrel of oil reaches the $200/barrel range. The author I wish to recommend is: James Howard Kunstler. His best book is: Too Much Magic. The society in which we live is a result of the existence of cheap oil. Let me name a few items looming large on our cultural landscape: the giant interstate highway system, and its creation: suburbia, with its yellow school buses and big schools with their 3000-student enrolments; megacities, with their skyscrapers; (did you ever wonder how much energy it takes to operate the toilets and water faucets on the 34th floor?). Ask yourself what this will do to those gargantuan boondoggles like the California Water Project. And this is only the beginning. Imagine, for a moment, the fate of Phoenix or Las Vegas, when there is no more power to operate the air conditioners—and then apply this idea to the rest of the country, and you will begin to understand the future. And all those shopping malls? The parking lots may not all be empty, but people will be living in the cars.

And there is more: Our mental world has been thoroughly sculpted by oil. There are propositions that have “stood to reason” for so long that we hold them to be “self evident.” Cheap oil has not been uniformly beneficial. It has created the solipsistic human, one who commutes and shops with the aid of an oil-driven box with wheels. We all move around in, and inhabit, boxes; for that’s the way we live.

The electronics that makes my little laptop computer possible, also makes it possible for a corporate-linked government to eavesdrop on every key-stroke, every phone call. Why is this? They do it because they can! Remember what Aldous Huxley said about the hidden cost of the technology that makes us all prisoners! And that huge building, the one that the NSA has created in Utah in order to store ‘yottabytes’ of information? I have heard that this contraption uses twice as much energy as does Salt Lake City, and few of us will miss it when its lights go out.

So, what will day-to-day life be like? The show will go on, but doubtless it will have a much smaller cast. Beyond this, I don’t know. I do know that societal cohesiveness, a bulwark against anarchy, will be
essential to survival—and this implies something personally distasteful to me: conformity, social control. We may well get a replay of the Middle Ages, (but with worse music). However, this scenario may have one saving feature: life on earth may survive. And that, to me, is everything! Mother Nature probably regrets having turned the earth over to the apes, i.e., Us.

Lord Kelvin, as you will remember, could also visualize two clouds on his scientific horizon. I believe I can discern a third cloud. If you know anything about Wall St. and the actions of the Federal Reserve, you will understand what I am saying. As of today, the stock indexes are overvalued by about two to one. In short, there is a monster bubble. Part of this is due to the fact that corporations are repurchasing their own stock. For another thing, speculators have been buying stock “on the margin.” This means that they buy stock with money that they borrow from their investment bank. As long as the indexes continue to rise, this tactic works. But once the indexes turn downward, the bank must get ‘a transfusion’ of money from the speculator—the guy who has spent his last dime on stock certificates. So the bank puts out a ‘margin call.’ The speculator is required to return some, or all of the borrowed money. But it no longer exists. Every time this has occurred in the past the result has been a ‘crash.’ What I have outlined is merely part of the problem. Our economic house is built on toothpick foundations, and the result will be an avalanche. You ask: When will the crash occur? I don’t know! But I do know one thing. It will occur! Betting on human short-sightedness, stupidity and greed is betting on a ‘sure thing.’ Compared to the effect of Global Warming, this is the good news.

The end of the medieval world was accompanied by a slow societal collapse, wherein the old institutions, the old attitudes, the old forms disappeared. It took nearly six centuries in Europe (1337-1918) to complete the transition. By the time this show is over, all of our present expectations, those propositions that “stand to reason,” will have been discarded and forgotten. The old ‘forms’ will have been discarded. And we will not have such a long grace period to adjust to our new situation.

Let me end this book on a more cheerful note. If we do not succeed in “cooking the world for dinner,” we will be forced to live severely within our means. But Modern Life is absurd, in that there is an absence of meaning. After the collapse, there will be no more television, no automobiles, no National Security Agency. Transportation will be severely circumscribed. When computers break, no one will remember how to fix them. Horses will be seen more often on the decayed roads. Ultimately new engines of social control will doubtless be constructed, and we will be forced again to contend with despotism. But after the fall of the Roman Empire, at least 600 years elapsed before the kings and popes managed to reestablish social control. Sometimes it is useful to take the long view. Modern Civilization has been a quasi-solution, and we are awash in Residual Problems. So weep not!
APPENDIX A

AN INTRODUCTION TO WAVES
...and their nomenclature

Wave Nomenclature

There are certain things you need to know about waves, in order to talk about them, and to describe them.

1) The most basic waveform is called sinusoidal. You can think of it as the shadow against a wall, made by a point P on the rim of a circular wheel, as the wheel rotates evenly. The shadow will move up and down as the wheel rotates. We can capture the path of the shadow of the point P upon a moving strip of photosensitive paper. We shall consider this process to last forever, so that the wave will have no beginning and no end. It’s like viewing an endless, moving piece of corrugated cardboard. Fig. XA1

2) If you freeze this pattern in time, as you would with a camera, you will see that certain of its features will have a monotonous permanence about them. They are (a) the amplitude $A$, and (b) the wavelength $\lambda$.

3) If you imagine your field of view to be sufficiently constricted to that you can see only one point on the wave as it marches forward, that point will be seen to oscillate up and down with an amplitude of motion equal to $A$. As the point oscillates through one complete cycle in a time $T$, (called the period of the wave), the wave would have traversed one complete wavelength $\lambda$ in space.

4) Thus, since the speed of the wave’s motion, $v$, is equal to the distance traveled, $\lambda$, (one wavelength), divided by the time necessary to cover that distance, (one period of the motion $T$), the speed of the wave is given by the expression: $v = \lambda/T$. 
5) Now let’s talk about the Frequency of the wave’s motion. If the wave cycles through one period of its motion in T seconds, the frequency, the number of waves per second, is given by \( f = 1/T \), (because \( f/1=1/T \)). Therefore the formula for the velocity, (from section 4)), is:

\[
v = \frac{\lambda}{T} = \lambda f.
\]

6) The next thing to notice is waves get reflected when they hit boundaries. If the wavelength of the wave bears just the right relationship to the dimension of the container that encloses it, the reflected wave and the incident wave will reinforce each other to produce a stationary, or standing wave. To see how this works imagine a wave on a string, a string that is tied down at both ends. Since the ends of the string are tied down, they can’t move. From this we can see that there must always be a “longest standing wave” for any string having a given length \( L \). To see why this is so, here is a drawing of one such “longest standing wave.” The key point is that if we try to make the wave any longer, it will violate the condition that the ends have to be tied down. Fig. XA2

\[
\lambda = 2L; \quad f_1 = \frac{v}{2L}
\]

7) Notice: There can always be found shorter standing waves that can be accommodated on the string; but these waves still have to satisfy the requirement that the ends of the string can’t move. Note: that each time we use a shorter standing wave, we are adding an extra half-wave to the string. This arrangement always enables us to describe the relationship between the wavelength of some arbitrary wave, (call it the \( n \)-th wave), and the length of the string. Here are pictures of some of these shorter waves, showing the mathematical relation that their wavelengths must always bear to the length of the string. Fig. XA3

\[
\lambda_1 = \frac{2L}{1}, \quad \lambda_2 = \frac{2L}{2}, \quad \lambda_3 = \frac{2L}{3}, \quad \lambda_4 = \frac{2L}{4}, \text{ etc.}, \text{ so that: } \lambda_n = \frac{2L}{n}
\]
8) Since the frequency of the wave is always related to the wavelength by the relation:
\[ f = \frac{v}{\lambda}, \] [See Part 5) above],
and, since the wavelength in turn is related to the length of the string by:
\[ \lambda_n = \frac{2L}{n}, \text{ so } f_n = nf_1. \]

9) Any time you see a string in vibration, it is almost always going to be vibrating in two, three
or more of its possible modes of oscillation at the same time, independently! This is one of the most
beautiful aspects of nature, because it makes music possible!

10) Once you have read and understood Sections 1) through 9), you should be able to describe
any wave motion as a combination of sine waves, which play a role much like the ingredients in a
recipe for cookies. This, incidently is how musical synthesizers work.
APPENDIX D
How To Understand The Uncertainty Principle
By Measuring The Distance Between Teeth
On A Comb

1) The Uncertainty Principle For Position And Momentum
Below you will find several drawings, each of which depicts a kind of wave.

The first drawing, labeled [A], looks very much like the teeth on a comb. Suppose you wanted to measure the “position” of the center of the group of teeth, (implying an estimate of a point somewhere in the middle of the group). You can see right away that you would get a highly imprecise result, since the teeth are spread out over a considerable distance. So the uncertainty associated with an attempted position measurement is quite high.

On the other hand, suppose you wanted to measure the spacing between those teeth. One could always go about it by carefully measuring the spacing between two adjacent teeth, but there is a possibility for error at either one of the teeth. How can you be sure that the ruler is lined up properly? But if you are shrewd, you will see that the places where error is possible are confined to the two ends of the two ends of the comb, and that you can do much better by measuring the total length of the comb, and then dividing this by the number of teeth (minus one). The more teeth you count, the smaller fraction of the length is devoted to the error-prone ends. Thus, to measure the distance between adjacent teeth, corresponding to the wavelength of a wave, you want a wave train that is spread out over a considerable distance.

Now is the time to remember the formula for the de Broglie wavelength. It is:
\[ \lambda = \frac{h}{p}. \]
This is very important. What this formula says, is that if you know the wavelength of a quantum, then you know the momentum. Therefore you can see that a good momentum measurement requires a long wave train. But “a long wave train implies that you can’t tell clearly where the wave IS! That is why knowing the momentum of a quantum “particle” creates an uncertainty in its position, and vice-versa.
The uncertainty in the momentum is inversely proportional to the uncertainty in the position, just as Heisenberg claimed.

2) The Uncertainty Principle For Time And Energy
Now that we have gotten into the spirit of this thing, let’s imagine that the comb (& thus its wave) is moving across our field of vision, and we want to measure its energy. Now is the time to remember the Planck formula for the relationship between energy and frequency. It is:

\[ E = hf. \]

Once again, measuring the frequency, the number of times per second that the wave executes a cycle, involves counting the number of cycles per second. And once again, the shrewd way to do this is to count a large number of cycles, and then to divide by the total elapsed time.

Below you will find a set of drawings, bearing a suspicious resemblance to the ones shown above. This should come as no surprise, since the underlying idea is the same in both cases. Once again, the drawing labeled (A) depicts a wave that is executing a large number of cycles (or a comb with lots of teeth). Therefore the uncertainty in its energy is relatively small. But WHEN did that wave cross your field of vision? It’s harder to tell, because it took a while. If you try to narrow down the time when the wave arrived, you have fewer vibrations to work with. Therefore you can’t measure the frequency as well as you would like. And the frequency is proportional to the energy. Therefore you have a greater uncertainty in the energy.

So, as you can see, the idea is not all that mysterious. You can convince yourself that this is true, merely by playing with a comb!
For those of you who desire a more complete discussion of the way in which polarization can be used to show that Bell’s Inequality is violated, here is the way Nick Herbert explains it.

If the two polarizers are set parallel to each other, every time a green photon passes through the right-hand polarizer, a blue one passes through the left-hand polarizer. This is simply an observed fact. Let’s give the probability wave an amplitude of one unit, since the probability of having photons match at both ends of the apparatus is equal to one.

![Circle Diagram]

Fig. 1 Shows a circle of radius equal to one unit, with a vertical arrow touching the circle.

**Part I of our Argument**

What happens if you tilt the right-hand polarizer through an angle of 30 degrees to the one o’clock position? Then the probability of the photon passing through the polarizer decreases by 25%—that famous mis-match. Why is this the case? Answer: (here draw a 30-60 right triangle in Fig. 2). From your high-school geometry, you may remember that the side opposite the thirty-degree angle has a length equal to one-half the length of the hypoteneuse. Here the side opposite the 30-degree angle is related to the degree of mis-match. The amplitude to which it corresponds is equal to the square of the length of the side, or \( \frac{1}{4} = 25\% \). See Fig. 2 below.

![Triangle Diagram]

Fig. 2, with arrow pointing to one o’clock.
Part II of our Argument

What happens when one of the polarizers is tilted by 30 degrees to the right, while the other is tilted by 30 degrees to the left? Then the angle between them is 60 degrees. The sum of the squares of the sides of a right triangle is equal to the length of the square of the hypoteneuse. The square of the hypoteneuse is just 1. (That was easy; just look at the diagram). The square of the side opposite the 30-degree angle is \( \frac{1}{4} \). Thus the square of the side opposite the 60-degree angle is \( \frac{3}{4} \).

Fig. 3. Show circle with arrow pointing to two o’clock. This gives the probability that a mis-match will occur when the two polarizers are tilted at 60 degrees relative to each other.

Part III

What would a follower of Einstein have expected? He/she would have expected that the reason that the polarization was found to be in the vertical direction was that it had been that way in the first place, and that is why the polarizer had let it go through! Therefore Einstein’s view and the quantum mechanical view would have coincided through Part I of this discussion: namely, a mis-match of 25%.

But the follower of Einstein would have taken a radically different view of Part II. He/she would have insisted that both the left-hand and right-hand photons had had a vertical polarization initially. And that each one, taken singly, would contribute a mis-match of 25%. This would result in a total mis-match of at most 50%. But Mother Nature, (herself a quantum creature), doesn’t work like that!
Appendix F
Quantum Consequences:

Dear Reader,
The book that I wrote for the text in Physics 303 included a copy of Richard Feynman’s lecture: "Probability and Uncertainty," from his series: "The Character of Physical Law." Unfortunately I don’t think I do this any longer. I am allergic to lawsuits. But I want very much for you to watch a video of this lecture, and maybe even buy the complete series in book form. To gain access to these, all you have to do is use Google, and ask for “Richard Feynman.”

Frankly, I didn’t like the previous version of this chapter, the one that appeared in the textbook. It sounded arrogant and combative. This new version, I think, is better, less professorial.

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1. A Bit of History!
That wonderful physicist, Richard Feynman, once asked: If all scientific knowledge were to be destroyed in some cataclysm or other, so that if only one sentence were to survive, what statement would contain the most knowledge in the fewest words? His answer was that: “all things are made of
atoms.” The word: “atom” comes to us from the Greek language: a-tomos, which taken literally means: *indivisible*. Feynman’s “atoms” possessed additional properties; namely, that they attract each other when they are at a little distance apart, but repel each other upon being squeezed into one another. But did he really believe this statement to be true in some absolute, final sense? Certainly not! What he probably meant, was that the belief in their existence had produced a vast intellectual revolution, one that spanned several centuries, and created a tidal wave of scientific discoveries. Thus the atom was truly a seminal concept. But all concepts are merely mental constructs, and thus are subject to revision in the light of experimental results. The atom is no exception. As Feynman himself said: “The principle of science, the definition almost, is the following: *The test of all knowledge is experiment, (my position, exactly!)*) Subject to what we have learned from experiment, we must face up to the fact that atoms, in the Greek sense of the word, *do not exist.* “Atoms” are really composite creatures. As we all must know by now, it can be said that atoms consist of massive nuclei, attended by a retinue of electrons. (As long ago as the year 1940, this was common knowledge to me and my friends in the ninth grade at Aptos Junior High School).

A good part of the twentieth century was taken up with the construction of more and more powerful “particle accelerators,” in the hope of probing those massive nuclei, to examine their constituents. The model was the “Russian Doll,” inside of which there was supposed to be other, smaller dolls, and so forth. The goal, (in which we all devoutly believed), was to find the Fundamental Particle, the “tiniest” doll, the one that all the other particles were “made of,” the new Philosopher’s Stone. True, by the 1960s, many physicists were beginning to have their doubts about this way of looking at the world. But the notion had already taken hold, that down at the bottom-most level, there must exist a tiny particle, indivisible, whose properties constitute the cause of everything in the universe; and this notion has developed a vice-like grip on the popular imagination. As a result, physicists *can’t stop* talking that way, even when they know that it’s absurd!

Over that time, a “standard model” has been constructed, whereby we say that atoms are “made of” protons, neutrons and electrons. And protons and neutrons can be thought of as being “made of” entities called “quarks,” which are held together by “gluons,” and so on, (but not ad infinitum). But a certain amount of sophistication has also crept into our way of describing the world, and in the course of this chapter, we shall see that there are limitations, unsuspected, to the meaning of words such as: “substance” and: “made of.” We shall talk about this problem later in the chapter. But first it is useful to examine a bit of history, for the notion of the primacy of “atoms” has had a profound effect upon the Western Mind, ricocheting far beyond the narrow confines of the physics departments. The doctrine that atoms possess a final explanatory power, is called “radical atomism,” or “materialism.” It implies that “substance” takes the place of “relation.”
2. The Role of the Atom in the Evolution of Materialism
The fifth century BC marked the budding of Greek philosophy, and it was at that time that Democritus of Abdera produced the idea that I shall call: radical atomism, summarized in the epigraph at the heading of this chapter: “By convention sour, by convention sweet, by convention colored, in reality nothing but atoms and the void.” As we have seen in an earlier chapter, an appreciation of Greek language and culture came late to Italian scholars, but at the time of the early Roman Empire, in the first century BC, Titus Lucretius, a Roman, was able not only to demonstrate a firm understanding of atomism, but could set it down beautifully in clear Latin verse, understandable to any educated Italian. The title of his long poem? “On the Nature of Things”—("de Natura Rerum"). After the Empire had collapsed (476AD) there was a millennium-long hiatus, until the poem again came to light in Roman Catholic Europe in the early Renaissance (the year 1417), when it was about as welcome as ants at a picnic). But two centuries later it was clear that Galileo knew all about Lucretius; (though in his writings, he always managed to avoid the ‘a’-word). Instead, he used certain code words, which really meant the same thing). If you read Galileo’s words as quoted in Chapter Two, you will notice they do have a certain chill, depressing tone about them. How to describe this? For one thing, the richness of experience has been reduced to a pale, starved facsimile of the original. Hence the name ‘reductionism,’ a subject we shall discuss later in this chapter.

3. From Atoms to Mechanistic Physics
Let’s start with a simple example. Galileo is doing the kind of physics experiment that makes us all feel comfortable; he is rolling a ball down an inclined plane, measuring how long it takes the ball to roll through a given distance. (This experiment is not as easy as it sounds; for one thing there were no stopwatches in the seventeenth century). Despite this handicap, what he found was that the distance covered by ball varied with the square of the time: a brilliant discovery! He also found that if you slide an object down the inclined plane, that its acceleration does not depend upon its mass! At this point Galileo gets tricky: he recognizes that there is an important limiting case: one where the plane's angle of inclination is ninety degrees. This, of course, corresponds to free-fall! In this manner he was able to show that the rate of fall of a falling body is independent of its mass! Considering the difficulties that are involved, (air resistance, getting a straight piece of wood for the plane, lubricating the various parts, and Galileo’s failing eyesight), the experiment was a masterpiece. But the real masterwork was his showing that a law of nature could be expressed in simple mathematical terms. He had found a key, and had turned it in a lock, and a magic door had opened.

Once Galileo’s work had been smuggled out of Italy (1640) and had been made known to certain like-minded people in Holland, France and England, ‘the cat was out of the bag.’ In a very short time atomism was combined with Galileo’s science of mechanics to produce the philosophy of Mechanism: the world seen as a machine. One of the very great mathematicians of his time was Blaise Pascal,
(who was also very religious). He was born in 1623 and died in 1662, (when Newton was only 18 years old), but he could already see the full consequences of a disenchanted mechanical universe, one consisting solely of “atoms and the void.” He even exclaimed: “The eternal silence of these infinite spaces terrifies me.”

By the year 1687, Isaac Newton had discovered three laws of mechanics. Of most interest to us here is his Second Law, which states that the acceleration of a body is proportional to the force exerted on it, and inversely proportional to its mass. It looks like this: \( \mathbf{a} = \mathbf{F}/m. \) Here was an even more powerful skeleton key! Knowing the acceleration makes it possible to calculate the velocity; and knowing the velocity gives you the position. Therefore, given the force acting on a body, you can predict its position for all time!

At the beginning of the 19th century there were many great mathematicians in France. But perhaps the greatest of these was Pierre Simon de Laplace, and it was he who wrote the words that were to be the intellectual and psychological “flagship” of the mechanistic materialists who were to hold mental dominion over that century, as well as over a good part of the following one. Here is what Laplace wrote:

“We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes.”

This “intellect” is often referred to as Laplace’s demon. Laplace, himself, did not use the word “demon”, which was a later embellishment. In the original French, he simply referred to: “Une intelligence... Rien ne serait incertain pour elle, et l’avenir comme le passé, seraient présent à ses yeux.”

What this means, is that for Laplace the universe is a vast machine, (today we would call it a computer; fashions change), whose parts follow fixed trajectories in time, in accord with strict deterministic laws. One example of this is the motion of planets together with their moons about the sun. Planetary orbits actually functioned psychologically as a sort of “teaching model” for human behavior, and their regularity produced a feeling of comfort that bordered almost on the spiritual. And in this way “Mechanism” became the ruling paradigm. “Just give us the correct equation, and the same initial conditions, and every object will follow the same trajectory.”

The thought that we live in a universe where reality seems to comprise the constant clicking together of deterministic ball-bearings is, to be sure, a dispiriting one (literally), but it has contributed much to the development (and derangement) of the “modern mind,” (at least for the minds of my generation), when
it gave rise to what has been called “the culture of despair.” The reason for this name seems to be that in 1926, in his book: “Why I am Not A Christian,” philosopher Bertrand Russell wrote cheerfully: “…only on the firm foundation of unyielding despair can the soul’s habitation be safely built."

4. And Now For The Revolution: We Arrive At The Departure Point –From Mechanism
Our first goal is to demonstrate that the search for a primordial atom—a so-called “fundamental particle”—was really an unsuccessful attempt to find a suitable metaphor for Reality. After all, who appointed us “the reality sheriffs” for the universe? We only know what it seems like to us; we don’t know, (in any final sense), what it is. **Photons**

Let’s start with photons, since they appear to represent the simplest example of the thing I want to show you. Further, let’s use a laser, a device producing waves of essentially the same frequency. Since the energy is related to the frequency by Planck’s equation:

\[ E = hf, \]

Then these photons will all have the same energy. And since the wavelength is related to the frequency by the equation (See Appendix A):

\[ f = c/\lambda, \]

They will all have the same wavelength.

And since the momentum is related to the wavelength by de Broglie’s relation:

\[ p = h/\lambda, \]

the photons will all have the same momentum.

In addition, photons possess a characteristic angular momentum. We can imagine that, as they travel, (always at speed c through a vacuum), the planes of their electric and magnetic fields rotate like a kind of screw. This property is, in a vacuum, called circular polarization. The angular momentum of the photon is \( h/2\pi \), where \( h \) is, again, the (now) familiar Planck’s constant. It is important to recognize that every photon has the same angular momentum.

Thus all the intrinsic defining properties of photons depend entirely upon their energy and angular momentum. All photons of a given energy and polarization are absolutely identical. There is absolutely no way to one of these from another: they are perfect clones, bereft of any telltale vestige of personality—of identity.

We may reason further. Since the defining characteristics of the photon are just its energy and polarization, *then these*, the photon’s only distinguishing attributes, (plus the fact that the photon travels at light-speed in a vacuum), *are* the photon! Any sentence attributing more qualities to the photon than those, must simply be meaningless, for there is no procedure available to detect the existence of such
extra qualities. That, we might say, is the complete “bar code” of “photon.” When we buy an item at the market, the item carries a “bar code.” In the quantum world there is no “item” beyond the “bar code!” Lesson: A photon is just one example of a quantum. They are all like that: collections of properties. Beyond this, there is “no there there.”

5. Does Causality Still Hold For Quantum-Mechanical Critters?
Let’s think about Galileo, rolling balls down that inclined plane. Every time he repeated a trial, the result had to be the same. If that had not happened, physics would have had a very different, (and undistinguished) history. So we can agree: In the world of classical physics the same causes must always produce the same effects. But there are exceptions to this rule. Let’s look at Airy’s rings.

This is a very simple experiment. We punch a tiny hole in a sheet of aluminum foil, and from the left side of the foil we shine a beam of laser light through the hole in such a manner that it illuminates a screen that has been placed to the right of the sheet of foil. We will see that something peculiar is happening on the screen. See Fig. F1

![Figure F1 Energy levels of positronium.](image)

From the point of view of classical physics we would expect to get a tiny dot of light on the screen: an image of the hole in the aluminum foil. Doesn’t light travel in straight lines? Apparently not! What we see is a kind of bull’s eye pattern of light and dark rings, called Airy Rings, named after the British
scientist, Sir George Airy, who calculated the radii of the rings in 1835. (By the time of Airy’s discovery people had become accustomed to the wave nature of light, and no scandal was reported).

But when we look at the matter from the standpoint of the Quantum Theory it becomes stranger yet. To see why this so, let’s reduce the amplitude of the laser beam until the photons arrive just one at a time, leaving dark specks of silver in the emulsion. After a while we see what is happening. At first the photons seem to strike the screen in a random way. But if we use progressively longer exposure times, (thereby collecting more and more photons), the dark specks begin to coalesce into the familiar Airy rings.

Now here is the astonishing thing. We know that every single one of the photons emitted by a laser is absolutely identical with all the others in its intrinsic attributes. They all propagate at light-speed c, and they all have the same vibrational frequency and their wavelength, is given by:

\[ \lambda = \frac{c}{f}. \]

And from the Planck and the de Broglie relations they all had the same momentum:

\[ E = hf = \frac{hc}{\lambda} = pc. \]

Since h (Planck’s Constant), and c, the speed of light, are measured constants, a look at the algebra should quickly convince you that, (with the exception of polarization), the frequency of the light determines everything there is to know about it: the wavelength, the energy and the momentum!

So, all the photons in the experiment are identical! And yet each one of them was observed to wind up in a different place. Therefore we know all there is to know, and it is still not enough. Classical causality as we know it has broken down. Equal causes no longer produce equal effects. We can no longer trust causality, that mainstay of Western thought. Why? Because the same causes have produced different effects!

6. Another Example: The Electron

Further, the same kind of analysis can be applied to the electron, or, (with a little persistence), to any quantum “particle.” One of the electrons attributes is its “mass,” simply its “rest energy,” (since Einstein has shown “mass” can be given by the famous equation):

\[ E = mc^2. \]

The additional members of the electron’s “bar code” are its electric charge, e, its angular momentum \( h/4\pi \), where h is the inevitable Planck’s constant--and one further number that arises when a nucleus requires the presence of an electron in order to be part of an internal “decay” of a neutron. And that is the electron’s complete “bar code”! All electrons have these intrinsic attributes, and no others; they are all identical clones! They are just “bar codes.”
You might ask: “Aren’t they particles? Aren’t they round and plump, with a fixed radius?” And I will reply: “If you make them behave like particles, they will. If the electron impinges upon a target, it will do so at what appears to be a single point. But if you make them act like waves, by performing a double slit experiment with them, they will act like waves, in the same manner as photons. You ask a “particle question,” and you get a “particle answer.” It is likewise with wave questions. We do not see nature in any other way than in the manner in which it interacts with our macroscopic detection apparatus.” And the radius of the electron? Have patience! We shall talk about this matter shortly. But be prepared for a surprise!

7. Nuclei, and other gross things

Without much error, one can speak of the atomic nucleus as being “made of” protons and neutrons. Each of these latter two types of “particle” is approximately 1833 times as massive as an electron, a fact that accounts for most of the mass of an atom. In the early 1960’s it was discovered that one could speak of each proton or neutron as being made up of “kinds” of particles called quarks; and it was to these, the quarks, that physicists looked, to account for the properties of protons and neutrons. They were to be disappointed.

And it gets worse. In the mechanistic tradition it had been assumed that the mass of, say, the proton, would turn out to be the sum of the masses of its constituent quarks. Instead it was discovered that the rest mass of the quarks produces at most a tiny fraction of the mass of the proton. The remainder of the mass of the proton is due to the energy of the extremely rapidly moving quarks. Why is this so? Recall: that by Einstein’s famous formula, mass equals energy divided by the square of the speed of light. There seems to be so much energy stored in the force-field that holds them together, that enough mass seems to be produced to account for what we see when we actually weigh a proton.

Clearly, we need to get out of the habit of thinking about mass as a fundamental feature of the universe. For the past thirty years this heretical thought has simmered on the back burner of science, but now it has come to a boil. In the words of Frank Wilczek, who was a member of the Nobel Prize-winning team that “weighed the quark:” “We’ve come a long way toward dethroning mass as a primary, irreducible property of matter.”

It is helpful to practice thinking like Michael Faraday (Ch. 8). It was he who stopped thinking of particles and started drawing maps of their effects in the surrounding spaces. These effects produced regions where the “state of affairs” was changed, vis-à-vis the way they had been in the absence of the charges. He called affected regions: “fields.” This became the way we quantum people think about the world. (1) The universe is a playground of quantized fields. (2) What we observe as “particles” are merely the energy quanta of these fields. (3) They only manifest themselves to us by interacting with us. So: “Get used to it!”
Now let’s return to the subject of mass. In order to find a place for the concept of mass, it was thought that there may be a kind of field—one which acts upon other fields, conferring a kind of inertia upon their energy quanta—and that this inertia would in turn be detectable in the laboratory as: mass. Further, since associated with every field is a quantum, one that can be discerned as a particle, we should make an effort to find that particle. Several years and billions of euros later, the particle was found, and was named the “Higgs particle” after the man who predicted its existence.

Lesson: There is no intrinsic property of “objects” called mass. It is conferred upon most “objects” by their interactions with the Higgs field. This is one of the facts of life.

8. What Happens When We Think About Angular Momentum?
In the world of classical objects, angular momentum is a property that they have when they rotate. I believe that we can discuss angular momentum without using the customary mathematical apparatus, simply by appealing to your intuition\(^4\), gained from your experience in sports. So it’s useful to think about spinning baseballs, footballs, and the “English”\(^5\) that we place on ping-pong balls. These balls are all rotating objects; they have finite radii, they have mass, and they spin.

First, let’s think about the photon. It has no radius, and no mass. But it does have a polarization vector with certain corkscrew properties, i.e., the vector rotates. This fact gives it an angular momentum \(\hbar/2\pi\). When we talked about electrons I warned you that a surprise was coming. It is here already, and we are only talking about photons, which we thought we understood. So, we had become accustomed to associating angular momentum with massive rotating objects, (5.5 oz. baseballs) and now here is the mass-less photon….

Next let’s examine the electron. If we want to retain our grasp on the familiar ways of Newtonian physics, we will find little comfort here. The electron does have a mass, indeed. But years of effort have been unable to disclose a radius for the beast. Any particle-like experiment reveals the electron as a dimensionless point. And yet it spins, with angular momentum \(\hbar/4\pi\)! A spinning point!

From the classical Newtonian point of view, it seems correct to say that angular momentum is a property of bodies that possess mass, and a finite radius, and just happen to be rotating. That’s the way we always talk. But experiments have driven us to the conclusion that it is really the other way around: that angular momentum often manifests itself in the behavior of gross classical objects, but its connection to them is not a necessary one! It exists all by itself!
Angular momentum is not a kind of “thing;” it is an attribute. It is autonomous. Spinning balls are creatures of angular momentum, not the other way around. Therefore we cannot really avoid the conclusion that what is happening in the universe is really a set of relations between “bar codes.”

9. Returning to the question: “What Are Things Made Of?”
Shortly before the year 1940, scientists came to realize that if two protons and two neutrons came together under the proper conditions, the element Helium was produced. What was noticeable was that the mass of the resulting Helium atom is less than that of the original ingredients: the two protons and two neutrons—by about seven parts in a thousand. (This figure is remarkable in its own right, for if it were to differ appreciably from its actual value, the universe as we know it, would not exist). What is striking about this is that it is counter-intuitive. Aren’t objects supposed merely to be the sum of their parts?

With the development of the first mammoth particle accelerators during the 1950s, matters only grew worse. After that time it became possible to arrange for one proton to collide with another, using energies markedly greater than the rest energy of an individual proton. Below are two examples a bizarre kind of reaction, one that became extremely common with the passage of time.

\[ p + p \rightarrow p + p + p + p \]

Here the symbol \( p \) denotes a particle called an anti-proton. It “looks” just like a proton, except its charge is negative, (and, given the opportunity, the proton ad its “anti-” will annihilate each other). A slightly more extreme event looks like:

\[ p + p \rightarrow p + p + p + p + \pi^+ + \pi^- \]

In the second example, the particles labeled: “\( \pi \)” are called \( \pi \)-mesons, (or simply pions) and constitute just one example of the various kinds of exotic beasts that emerged from the quantum jungle to bedevil physicists during the second half of the twentieth century. Today, events occurring in “high-end” accelerators feature hundreds of these and other exotic interlopers, none of which were “on stage” before the collision that produced them. It is not unreasonable to say that they were “created.”

There is absolutely no precedent for this kind of thing in our everyday life. If we examine the debris left over from firing two grandfather clocks at each other from cannons, we will find a shower of loose cog-wheels, springs, pendulums and broken glass; but what we won’t get is a barrage of alarm clocks and wristwatches. Toward the end of his life Werner Heisenberg expressed the problem with his usual forcefulness:

I will discuss that development of theoretical particle physics that, I believe, begins with the wrong questions. First of all there is the thesis that the observed particles such as the proton—consist of smaller particles: quarks—or whatever else, none of which have
been observed. Apparently here the question was asked: What does a proton consist of? But the questioners appear to have forgotten that the phrase ‘consist of’ has a tolerably clear meaning only if the particle can be divided into pieces with a small amount of energy, much smaller than the rest mass of the particle itself.

From the above discussion we can see that by the second half of the twentieth century, the traditional metaphors of Western Philosophy, had become *incoherent*! (We had to use one kind of logic for going to the grocery store, and quite another one, when we want to learn some of the innermost secrets of nature).

Once again we turn to Werner Heisenberg, who summed up this position admirably, (together with the tension that it has inevitably produced):

One extreme is the idea of an objective world, pursuing its regular course in space and time, independently of any kind of observing subject; this has been the guiding image from modern science. At the other extreme is the idea of a subject, mystically experiencing the unity of the world and no longer confronted by an object or an objective world; this has been the guiding image of Asian mysticism. Our thinking moves somewhere in the middle, between these two limiting conceptions; we should maintain the tension resulting from these opposites.

**10. The Quantum and the Particle: When is a Particle?**

Sidney Drell of Stanford University asked the above question in the title to an article appearing in *The American Journal of Physics*. The search for particles, together with what were supposed to be their inherent properties, was a kind of linguistic entrapment that had had its origin in early Greek philosophy. During the late 1940s and throughout the 50’s and early 60’s regiments of physicists around the world were engaged in an unrelenting search for new particles, (of which there were more than anyone had ever hoped for). At the same time they were trying to make sense of the plethora of particles that had already been discovered. The purpose of this search had been to find the truly Fundamental Particle—the one that all the others may be said to “consist of.” By the time Drell had written his famous article, the physics community had, by and large, arrived at the realization that Heisenberg had been right—that it didn’t really make sense to ask: “What does matter consist of?” (But under the tyranny of habit they often went ahead and did it anyway. And they still do, because they can’t help it! As the scorpion said in the fable: It’s my nature!)

In the early years of particle physics it had been taken for granted that you could treat sub-atomic particles in the same way you could treat gross, macroscopic objects. My main purpose in writing this chapter is to show you that this approach doesn’t make sense. After the middle of the 20th century
powerful particle accelerators had already produced an undigestibly large menu of these quantum entities, a fact which prompted Enrico Fermi, one of the truly great physicists, to exclaim: “If I knew the names of all the particles, I would be a botanist!”

What is the Higgs Particle? For some time now, physicists have noticed that people had given too much reverence to the idea that mass is ‘permanent.’ The principle complaint about mass is, of course, its convertibility into energy. Once you have watched the tracks of an electron and a positron as they meet and annihilate, mass no longer has the grasp on your imagination that it had when it was supposed to be an eternal fixture of reality. If you have been taught that the universe is made up of small ball bearing-like entities, the evanescence of mass brings about a crisis of faith. But then, how do you explain away the existence of mass?

Well, after more than a century of the Quantum Theory, we have been conditioned to think of the world in terms of ‘quantum fields.’ Peter Higgs reasoned that there must be some kind of quantum field that interacts with other quanta to bestow mass on some of them. And so the chase was on. The quantum of the ‘Higgs field’ had to manifest itself as a ‘particle’ in the context of a collision. So you can imagine the rest. Thousands of people worked together, sources of money were found, (I’ll skip the political ramifications), and after years of searching, the Higgs particle was found (at an energy of about 125 Gev).

So what does this show? It shows that ‘mass’ is like a disease; you catch it from Higgs field. If Democritus were alive, he’d be embarrassed.

But by the 1960’s some degree of order was beginning to appear; it had been possible to arrange these particles according to the symmetries of their attributes, and to study the ways in which one particle could decay to form another one. The emergent pattern looked strangely familiar; and we would do well to explore its outline by comparing two examples.

11. We Look Again at the Electron

We should all feel fairly comfortable around electrons by now, since they are absolutely indispensable to the functioning of our bodies, as well as our computers! But there is another thing…. It turns out that the electron has a twin, called the “positron.” It is identical to the electron in every respect save one; it carries a positive charge. Under the proper circumstances the electron and the positron can be made to orbit each other7, in a manner similar to the hydrogen atom, (the one we studied when we were following the adventures of Niels Bohr). In that case the electron and the hydrogen nucleus were doing a kind of dance. So, the positron and the electron form a kind of atom—and they, too, are doing a dance, one called “positronium”–except this time the positronium dance is truly a dance of death8, culminating rapidly in mutual annihilation of the dancers, for this is what always happens when particles and antiparticles meet.
But the dance does manage to last long enough for us to be able to study the various dance steps—that is, the transitions occurring between various “states,” i.e., energy levels. These transitions constitute the “spectrum” of positronium, in a manner entirely analogous to the spectrum of hydrogen unraveled by Niels Bohr in Chapter 9 of this book. See figure F2, below.

![Figure F2: Energy levels of charmonium labeled by their quantum numbers.](image)

The transitions are accompanied by the emission and absorption of photons, just as we saw when we looked at the spectrum of hydrogen (Figure 9-2). They occur between quantum states that are exactly analogous to those we encountered previously. That is why Sidney Drell chose positronium as an example.

So, here is something to remember: The energy differences between the states are very small compared to the rest energies \(E = mc^2\) of the electron and the positron. But they are still there! Therefore, an electron or positron in a higher energy state has a mass that is a tiny bit larger than the mass of the “same” particle in a lower energy state. Thus, if we wanted to define a particle by its mass, then the above diagram would be a mass spectrum!

But we talk about energies instead, because people who studied atomic spectra found it convenient to use that terminology. Now let’s look at an example that exhibits some minor differences, is essentially analogous to what we have seen in the case of positronium.

**12. The Charms of Charmonium**

Here is an example, now involving \(\pi\)-mesons, particles that we have met briefly before. They have acquired the name: mesons, because they were initially found to be intermediate in mass between lightweights like the electrons and more serious particles, such as protons or neutrons.
In a brilliant piece of work done in the early '60s, Murray Gell-Mann and George Zweig were able to show (among many other things) that we can talk about the meson as a composite of a quark and an anti-quark. (Note the analogy with positronium). These quarks also execute a dance, and exhibit a spectrum just as positronium does. Although the details of the spectra will differ, there remains an underlying similarity, because the two cases are analogous. The important thing is for us to see where that analogy holds.

The point of Drell’s argument is that there is a similarity between the patterns in the positronium diagram and those that we shall see when we look at the charmonium diagram. While the similarity is not quite perfect, it is close enough so that we can discern that the same kind of thing is happening in both cases. Behold! Fig. F3

![Figure F3](image)

The only difference is that: states of charmonium represent a considerably greater investment in mass-energy than those of positronium; and so it became fashionable to refer to the states of the former as “particles.” And this is precisely my point: that the animal we have become accustomed to speak of as a “particle,” (a word that triggers off the mental image of a billiard ball), can better be regarded as a quantum state, (an energy state belonging to a quantum field). This idea is to be treasured, for it is revolutionary, and beautiful. It may seem peculiar to you, (as it did to me when I was younger). But it is correct.

13. A Kind of Cosmic Jell-O
What, then, is a quantum field? This notion is an abstract one, but it will be helpful for us to use our imaginations. Many, (after a few puffs), have found it profitable to look upon the quantum field as a set of incredibly fine, invisible, ethereal interlocking bed springs! A Cosmic Jell-O, but with an essential difference: the quantum field cannot be said to be made of “matter”; it is not “stuff;” rather, it is a Jell-O of pure possibility!: the very stuff of the Schroedinger waves. If the quantum Jell-O is caused to vibrate, the corresponding quantum state can be regarded as being filled by a “particle.” In the final analysis it is a matter of language. But the words have been chosen to describe a picture in our minds. But is there
14. The Problem of the Void

We have seen that the mechanistic philosophers of the 17\textsuperscript{th} and 18\textsuperscript{th} centuries had conceived of the spaces of the universe as a cold, empty, dead expanse: a void. In the 19\textsuperscript{th} century an attempt was made to fill the void with a rarified material medium called the æther; (to accommodate the newly-found electric and magnetic fields). After Michelson and Morley had shown that there is no evidence indicating the existence of a material æther, the door was open for Einstein’s Theory of Relativity, which described space-time as a continuum, space and time being treated as inter-convertible. However, space-time didn’t appear to make the vast spaces of the universe appear any the less void.

15. The Mysterious Quantum Vacuum: “That Jello Again?”

When we look up at the sky on a clear, moonless night, we can observe the light of several thousand stars. This light, in the form of electromagnetic waves, is propagated through a space that seems to be nearly empty of matter. Yet, as the classical physicists of the 19\textsuperscript{th} century had noticed, a wave is an oscillation, so something really must be oscillating. But if there is no material æther what can it be that is oscillating like that? In the early days of the Quantum Theory physicists reasoned that the electromagnetic field must itself be quantized. The conclusion reached was that:

(1) “Empty” space must be full of ghostly oscillators\textsuperscript{11}, and
(2) These oscillators must oscillate in strict obedience to the laws of quantum mechanics.

Thus, even in the absence of “real matter,” that which had formerly been regarded as “empty space” must really obey the Heisenberg Uncertainty Principle. One consequence of this is that there must always be an uncertainty in the amount of energy present in a given volume of space. Thus energy may, in a sense, be “borrowed,” and for short periods of time, this will go un-noticed!

From Appendix B we see that the “energy form” of the Uncertainty Principle is:

\[ \Delta E \Delta t \geq \hbar /2\pi. \]

From this we can reason further, and see that for very short periods of time, it is actually possible to borrow enough energy to create (on credit) a particle-antiparticle pair. These fluctuations in the vacuum energy produce “virtual particles” which are continually coming into, and going out of existence, back into the eerie, probabilistic half-world from which they issued: the Quantum Vacuum.

As an aid in visualizing the Quantum Vacuum it is useful to imagine yourself in an airplane, flying over the ocean. From an altitude of 37,000 feet the surface of the ocean appears to be as smooth as a billiard table. But a person traveling aboard a ship may experience monstrous waves roiling the surface of that ocean, tossing the vessel wildly from side to side. The Quantum Vacuum is like this, and the
fluctuations of the quantum oscillators are like waves on the surface of a quantum sea. Some fluctuations have enough energy to create virtual particle-antiparticle pairs, such as electrons and positrons. If there is enough energy in one of the collisions produced by a particle accelerator to “pay back the bank,” those virtual particles will become “real,” and will leave a record of their existence. According to the great physicist John Archibald Wheeler:

No point is more central than this, that empty space is not empty. It is the seat of the most violent physics.

Why is this so? We have seen that space can be thought of as packed full of quantum oscillators, in the same sense we spoke of in connection with the Blackbody radiation problem—the one that had make the Quantum Theory necessary in the first place, (See Chapter 8). For another thing, every quantum oscillator possesses energy, even if it is in its lowest possible quantum state. Thus the total amount of energy that seems to be stored in the Quantum Vacuum is greater than the rest energy of all the “matter” in the known universe—all the stuff—the billions of galaxies, each with its billions of stars. Wheeler expresses this idea in the following manner:

Elementary particles do not form a really basic starting point for the description of nature. Instead, they represent a first-order correction to vacuum physics.

In some mysterious way, all the apparent stability of the world is built upon this orgy of creation and annihilation. Millennia ago the Hindus intuited the true impermanence of the world in the myth of the Dance of Shiva, in which the god calls worlds into existence—worlds that might endure for eons, ultimately to be snuffed out, only to have other worlds rise from their ashes. Astonishingly, this view seems in accord with current thinking in the field of cosmology. The Dance of Shiva is an apt metaphor for the dynamic, impermanent nature of the universe—a dream, one that can be obliterated in the blink of an eye.

16. What is the evidence for the Quantum Vacuum?
The first experimental evidence for the Quantum Vacuum was an extraordinarily small correction to the Balmer Series in the hydrogen spectrum. First observed in 1947, this correction, called the Lamb Shift, was only one part in $10^{11}$. But since that time other effects have been detected—the most noticeable among them being the Casimir Force. If you wish to know how this works, you have to understand that electromagnetic waves exert a pressure on material objects. To measure the Casimir Force we place two metal plates at a very small distance from each other. We then discover that they will experience an attractive force. The reason for this is that the region between the plates can’t accommodate as many waves as can the region outside the plates. And electromagnetic waves exert a force proportional to the number of waves.
17. The Buddhist View and Heisenberg’s Middle Way

Since the Scientific Revolution of the 17th century until recent times, the dominant themes in the thinking of scientists have emerged almost wholly from Western Europe. What I am tempted to say, is that this mental set has really been an offshoot of European colonialism. So, when the progenitors of quantum physics grappled with their inability to harmonize the strangeness of their new subject matter with their old ways of thinking, they were forced to reposition the pillars of their philosophical foundations. Fortunately, students in Europe and America scholars had begun to discover the intellectual and spiritual treasures of Asia as early as the 18th century, so some of these concepts were no longer considered to be exotic.

Bohr, Schroedinger and Heisenberg all found certain aspects of what is recognized as “Eastern Philosophy” to be more in harmony with the Quantum Theory than anything that could be found in the Western Rationalistic Tradition. We must always reason in a manner ruthlessly consistent with the empirical data. This has been the scientific ideal: (Good luck with that). But this time our investigations have led us to a strange place. As Heisenberg put it:

The hope that new experiments will lead us back to objective events in time and space is about as well founded as the hope of discovering the end of the world in the unexplored regions of the Antarctic.

So, we have to look at traditions where objective events tend to be absent, and one such place is Buddhism. The central insight of Buddhist philosophy is: the non-inherent existence of all phenomena. According to this teaching, what we observe in the world is purely relative in nature, and nothing around us has any true, final, self-nature. All that we actually perceive are relations. The “things” between which the relations seem to occur are as evanescent as smoke, because they exist only insofar as they participate in those relations. When we intellectualize features of our experience, we are inevitably driven to make distinctions. In doing so, we must create “pairs of opposites,” (this and not that), where before then there had been a seamless whole. The Tantric Buddhist Lama Anagarika Govinda expressed this principle in the following way:

The Buddhist does not believe in an independent or separately existing external world, into whose dynamic forces he could insert himself. The external world and his internal world are for him only two sides of the same fabric, in which the threads of all forces and of all events, of all forms of consciousness and of their objects, are woven into an inseparable net of endless, mutually conditioned relations.

According to Buddhist analysis, belief in the inherent existence of phenomena feeds back into us, creating the illusion of the inherent existence of the human ego. In the words of the Dalai Lama:
How do self-attachment and so forth arise in such great force? Because of beginning-less conditioning, the mind holds tightly to “I”, “I” even in dreams; and through the power of this conception, self-attachment and so forth occur. This false conception of “I” arises because of one’s lack of knowledge concerning the mode of existence of things. The fact that all objects are empty of inherent existence is obscured, and one conceives things to exist inherently, the strong conception of “I” derives from this. Therefore, the conception that the phenomena inherently exist is the afflicting ignorance that is the ultimate root of all afflictions.

An important result of Quantum Theory is that no observation can ever be made of the world, or of any interaction within it, without the exchange of at least one photon—the bare minimum requirement. Further, the properties of a quantum entity depend crucially upon which properties we choose to measure. And what is a measurement, or an observation—but a relation? From this we can appreciate the Buddhist point of view. One is even tempted to say that if there had been no Buddhism, quantum physicists would have had to invent it. We only observe relations, not “things.”

The relative character of phenomena has been expressed by quantum theorist Henry Stapp in the following way:

The observed system is required to be isolated in order to be defined, yet interacting in order to be observed.

Unsurprisingly, this is in accord with a remark by Werner Heisenberg:

What we observe is not nature itself, but nature as exposed to our method of questioning.

Notes to Appendix F:

1. “La silence éternel de ces espaces infinis m’effraie. Pensees 206.
2. A supporter of Einstein probably would have said: “Wait! This is impossible! There must be some mysterious ‘wheels within wheels’ inside the photon: hidden variables, because in classical physics, similar causes always have similar results.” But as we saw in Chapter 12, the search for hidden variables has been a failure.
4. Classically, the angular momentum of a rotating object can be thought of as that property which makes it impossible to diminish the speed of rotation without “torquing” the object. You can’t ever change angular momentum without applying a torque. You will note that speaking classically, angular momentum is expressed as the inherent property of a rotating massive object. Quantum-mechanically, this is nonsense.

5. For a more technical classical treatment, see the excellent: Classical Dynamics of Particles and Systems, by Marion and Thornton, Harcourt, Brace and Jovanovich, NY, 1988.


7. When the electron and the positron get into each other's proximity, they proceed to annihilate each other, producing a pair of extremely energetic photons. This fact “speaks worlds” about the self-nature of things….

8. Actually, they orbit their common center of mass.

9. Drell points out that, since quarks cannot be produced as isolated particles, their existence can be compared to that of magnetic poles: a kind of phenomenon, incapable of being observed in an isolated form.

10. This magnificent theory was worked out during the years between 1925 and 1932, by Born, Heisenberg, Jordan and Pauli.

11. To get an intuitive feeling for an oscillator, think of a mass hanging from a spring, and bobbing up and down.

12. This result is a necessary consequence of Heisenberg’s Uncertainty Principle, which states that the uncertainty in energy, multiplied by the uncertainty in time, cannot be less than Planck’s Constant divided by $2\pi$. Thus the Quantum Vacuum can be described as a vast Energy Bank—really Too Big To Fail! It is possible to make small withdrawals for reasonable periods of time; large withdrawals however, can only be made for short periods.

13. Virtual particles cannot become “real” in the absence of an interaction/observation. Thus they reside in the same limbo as the rest of the Schroedinger wave functions.

14. This force has been measured by Steven Lamoureax at Los Alamos National Laboratory, who obtained a result that differed from the predicted one by less than five percent, while the force that was being measured was less than a quarter of a billionth of a pound! An astonishing accomplishment. See the magazine: Science, Vol. 275, page 158, 10 January 1997.

15. In the 1780s an English judge, Sir William Jones, serving in Calcutta, discovered that the Indians were speaking and writing in a language related to those of Europe. Hindi is related to Sanskrit much as Italian is related to Latin. Sanskrit and English have a lot in common! They are called “Indo-European languages.” In the 19th century these commonalities attracted the interest of German thinkers, resulting in the development of the science of philology.