The Glory, Jest, and Riddle: Stephen Hawking and *A Brief History of Time*[1][2]

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This essay on Stephen Hawking's book A Brief History of Time *from a perspective of play was written, I think, in 1988. It got set aside because of my work on other things and only recently emerged. In reading it I find it fascinating that the work I am currently doing on brain, body, and movement were beginning to form at the time I wrote this essay. Were I to write this today, I would perhaps address the issues more in terms of neuroscience and cognitive science, yet I continue to believe that the only way to appreciate this book is from a perspective of play. I would likely also extend my discussion of play as well.*

Frankly, I believe that while huge numbers of people have bought Hawking's book, few have actually read it and those that actually finished it did so primarily as an act honoring the genius of a man producing a popular science book despite suffering ALS disease. I think the book is at best an enigma if not seen from the perspective of play. I once talked with a physicist about the book and indicated that I thought good parts of didn't make any sense at all if seen as simply a presentation of physics theory. He strongly defended the book, yet I suspected that he had not actually read it. I now think that the book might best be understood as literature rather than science, the better to appreciate Hawking's cleverness and perspective. I think Hawking is best understood in terms of the way we might read Borges who has an amazing ability to show the limitations, if not folly, of common perspectives by taking them completely seriously and carrying them out to the fullest measure. Hawking does this with physics and in doing so, I think he playfully and humorously, should anyone read the book closely enough to notice, reveals the limitations of physics.

One issue that I have thought about over the years since I wrote this essay is the impact and importance of self-actuated movement on the academic work. I have increasingly come to believe that in the long run the typically sedentary academic lifestyle has a significant and limiting impact on what academics think about and how they see the

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2 As inspiration for this title I want to acknowledge Jonathan Z. Smith whose doctoral dissertation is entitled "The Glory, Jest, and Riddle: James George Frazer and *The Golden Bough*." It is notable that Smith considers Frazer's classic work *sub species ludi*. References to Stephen W. Hawking, *A Brief History of Time: From the Big Bang to Black Holes* (New York: Bantam Books, 1988) will be identified by page number within the text.

world. It is well known that Stephen Hawking has long suffered from ALS and has little capacity for self-actuated movement or even speech. His ability to adapt to his condition is nothing short of heroic. It remains of interest to me to think about the relationship between his work and his limited experience of self-actuated movement. I think it entirely fitting that Hawking's work, in this book, is to come to an understanding of the universe and of all existence that is largely in terms of a grand theory of everything. There is a pretty clear sense that the universe exists in the mind of Hawking rather than Hawking existing as a bodied being in the universe. I think it also fitting to Hawking's limited bodily experience that the relationship Hawking draws between his theories and the experiential world, the world of moving bodies, is one of irony, paradox, and play.

"Eureka!" The shout erupts from the mouth of a white-haired slightly-stooped man whose eyes twinkle with youthful wonder. Scraps of paper, discarded notes litter the office about him. Diagrams and figures flood the chalkboard. Massive tomes and computer printouts are piled everywhere. Blue-green mold floats in forgotten cups of coffee. On the desk a huge sheet of paper covered with mathematical scrawl seems to glow in the otherwise dimly lit room, though it may be reflecting the lighted computer screen. Stephen Hawking was right! That fateful day has arrived--the unified theory, the complete theory, the grand theory of everything, has been achieved.

As I deal with the news, though I rejoice in the wonder of it, I feel tinges of the nostalgia I began to anticipate years ago when I contemplated the course for unity and wholeness set by Einstein. Why do I not feel comfort that even these complex and ambiguous feelings are somehow explained somewhere in the incomprehensible numbers and symbols on the desk of some genius? Even my failure to be comforted must be explained there too. This is not the end of science; no need to worry about that. But it is an end to the most exciting phase in the history of science, maybe of human existence. Hawking said, as I recall, that it "would bring to an end a long and glorious chapter in the history of humanity's intellectual struggle to understand the universe." (167) What's left is only the working out of the details; the development of practical applications (which surely will continue indefinitely); and the great challenge of explaining to non-physicists and non-mathematicians like me what it all means. These important tasks will take decades, maybe even centuries.

Someone should ask the eureka-man to consult his theory and give us a few hints. Don't we need to plan budgets, start new programs, inform the government (surely there are military implications, new weapons possibilities), or do something? But maybe it doesn't really matter. A complete unified theory knows whether or not it is to be consulted in the course of our time-space cone. If the theory determines what we do, then why worry? Think I'll take the rest of the day off and play.

And with what shall I play? With the ideas presented by Stephen Hawking, of course. Though many have told his story (invariably illustrated with photographs of him, a slight man in a wheelchair, posed against a starry sky), some have advanced tiny criticism in the midst of grand encomia, still others have simply stuck to a description of the computer that allows him to speak.

A Brief History of Time: From the Big Bang to Black Holes presents a straight forward history of the background to and development of Stephen Hawking's ideas on a unified theory of physics. Its objective is to present the parameters of a unified theory as conceived by Hawking set in the perspective of a history of modern cosmology. Were the book confined to the presentation of the history, it would be valuable, but much less fascinating. The larger structure, the wider framing of the history, gives the book a tantalizing philosophical dimension. A background summary of the theory and its construction are needed.

All models of the universe are constructed using the same strategy. The laws which govern matter and energy must be discovered. These are assumed to apply equally throughout the universe. Given the complete description of the status of the universe at any one point, an application of the laws may project the status of the universe either forward or backward to any other point in time. Theories of the universe are deemed "good" if they are capable of making predictions that could be falsified by observation. Then, of course, it's nice if they aren't falsified right away. By applying the laws successively across time in either direction, a point is approached where the laws themselves collapse in limiting conditions. These are effectively the points of the beginning and the end of the universe.

Hawking proclaims the discovery that the universe is expanding as one of the great intellectual revolutions of the twentieth century because it furnishes the base for tracing this expansion backwards to the point of origin, the zero point. Put simply: given the rate of expansion, by knowing the present state of the universe the time of origin ought to be calculable. This is a bit like, though obviously enormously more complicated, those word problems we encountered in grammar school: Uncle Frank drove from his house one hundred miles away to visit you. If his average speed is fifty miles per hour, what time did he leave home if he arrived at your house at 6 p.m.?

As the calculations are done, apparently it is possible to continue using the known laws right up to, but not including, the point of origin. But, given that the universe appears to be expanding from a common point of origin, even from a common sense view, as one retraces the universe back to the point of origin, all of the matter and energy in the existing universe must be crammed closer and closer together. At the limiting point, the zero point, the universe took up zero space, thus it must have had infinite temperature and density. Since the description of the universe at the moment before its beginning is absurd in terms of the laws by which such a beginning condition was deduced, it must be concluded that this initial condition is a "singularity;" it does not go with the rest of the universe; it stands alone. There is a fundamental and necessary discontinuity between the conditions preceding the origin and those of the lawful processes of the universe which apply at the instant of its origin. The most broadly accepted account of the origin of the universe is that it started with a big bang, an instant explosion from singularity.

As early as 1970, in a paper delivered ironically at the Vatican, Hawking showed his suspicion of singularity theories. In *A Brief History* Hawking examines a number of the ways in which one might attempt to construct the link between the initial condition of singularity and the universe that we observe. One traditional explanation is theological. Hawking notes that according to one theological position, indeed he identifies it as the Vatican's position, God dwelt in the singularity and decided how and that it should manifest as the expanding universe. Hawking plays with this view throughout the book constantly linking it with that tired old view that as science progresses, God's role in the universe declines. An alternative view, Hawking identifies as the anthropic principle, begins with the obvious presence of intelligent human beings and infers that the universe came to be as it is rather than some other way because we are here to observe it. In other words, if it had come to be other than what it is, we wouldn't be as we are to observe it and account for its origins in the models we construct based on the laws we have discerned. Hawking hasn't found much satisfaction with either strategy: the first one must acknowledge the ineffable, the second, lucky chance. Since one cannot predict what will come out of a singularity (none of the known laws apply), Hawking holds that one may just as well cut the singularity out of the theory because it can have no effect on what we observe. Such a view led Hawking to work against the natural expectation regarding boundary conditions, the expectation of a beginning and an ending.

Classical relativity theory is the theory that requires that the universe originate in the big bang. Hawking and his colleagues studied black holes using classical relativity theory. Black holes, it is believed, may originate in the collapse of a star to zero space which is similar to, but obviously the inverse of, cosmic origins. To propose that the collapse of a star results in a singularity helps explain why black holes are in a sense comprehensible only as unlawful non-phenomena. While Hawking studied black holes in the rejected terms of singularity, it led him to the realization that "what singularity theorems really indicate is that the gravitational field becomes so strong that quantum gravitational effects become important."(133) This observation provided the link between the heretofore unbridgeable bodies of physics theory: classical relativity theory that accounts for the very large dimensions of the universe and quantum mechanics that accounts for the very small dimensions of the universe. Hawking set out to describe a quantum theory of gravity which, if and when it is achieved, will make it possible for the ordinary laws of science to hold everywhere even at the apparent beginning of time, thus eliminating any need for singularity. The resulting view of the universe is one in which time and space are finite but without boundaries.

To formulate such a theory seems beyond comprehension and surely it is for most. Hawking admits that he has only a few clues on how to proceed. Still it isn't difficult to construct analogies in order to catch a glimpse of the sort of difference Hawking proposes. It is a matter of shifting our point of view, shifting frames. For example, if our view is confined to the area below the surface of a diving pool, a diver bursts the surface (unknown to us as the undersurface) of the water (the domain of existence) and emerges finally as a whole body into the water where s/he swims about until s/he again bursts the surface, shrinking at the surface to a zero point where s/he finally ceases to exist. What appears from our limited vantage as a sudden explosive origin, a history of existence in the water (all of existence known to us), and a collapsing end, has a totally different appearance were we to see both above and below the surface. Here the existence of the diver is extended. The movement in and out of the water is no longer the origin and termination of the diver's existence, but only a phase, and in most senses the least important one, of the diver's action.

Hawking describes the universe in terms analogous to the surface of a sphere, but with added dimensions (visualization of this takes some imagination). Time is one of the dimensions of the sphere, virtually indistinguishable from a dimension of space. He describes time as a movement along the sphere from pole to pole correlating with the dimensions of the universe that expand throughout one phase (growing larger to the equator) and contract in another phase (shrinking back to the zero point at the other pole). Importantly, the beginning and end points are, like any other points, two points on the surface of the sphere. Thus he argues there is no breakdown in the laws that govern the processes of time and space throughout the universe.

To restate the analogy for further clarity: Were we to think of a sphere as Hawking suggests, we can easily acknowledge that on the surface of the earth there are infinite possibilities for journeys. Any point may be the beginning or end point of a journey. From the perspective of one taking any of these journeys, there are points in time and space that distinguish the journey. The time of the journey is in one sense discontinuous and unique to the journey, but the space is not, since it remains for others to traverse at another time. If I understand Hawking's idea about a unified theory, time in his theory would be analogous to space in our world of common experience, indeed he says it is indistinguishable from a dimension of space. Thus time may be entered and traversed beginning and ending at any points, moving in either direction, and it remains to be traversed again. Beginnings and endings are only event beginnings and endings and do not constitute any discontinuity, singularity, or abruptness. I will leave the mathematics to Hawking.

Playing along with Hawking we gain a new and exciting view of time and the universe. It replaces the big bang image as well as theological notions of divine *creatio ex nihilo*. Since this view is a creation of a human being and, in the universe, comprehensible and meaningful only to human beings, it seems to confirm the anthropic principle.

We live in a time that the world of science is so complicated and technical that we accept its proclamations without question. Hawking tells some humorous, but in a way rather frightening, anecdotes that emphasize just how few people understand the current scientific theories of cosmology, though he stresses that in time, as with the general theory of relativity, many will come to comprehend at least something of this new generation of theory. Most of us are grateful that Hawking has described his theories in more or less ordinary language free of calculations and equations. With good reason we are dumbfounded by the apparent mathematical genius of the man.

In this light it seems foolish to ask questions about Hawking's idea of a complete unified theory. But then only those who currently understand the theory and its mathematics are relatively free of this risk of foolishness. In parts of his book, Hawking writes with an openness and freedom, at some risk to himself, about his understanding of science--its goals and methods--and about the implications of the anticipated unified theory.

One of the most fascinating dimensions of Hawking's discussion may be articulated in terms of frames, frames of reference. Hawking's ideas about how to construct a unified theory make sense only if we confine ourselves to the frame of reference established by science. Agreeing, though tacitly so, to confine ourselves to this frame we are able to more or less follow the argument and comprehend, after a fashion, the resulting theory. Using analogy we can catch an occasional glimpse of even such notions as "a finite universe without boundaries" and "superstrings."

But marvelous things begin to happen when we take seriously the claims implied by calling a body of theory "complete and unified." The implication is that we need make no agreement, tacitly or explicitly, to confine ourselves to any particular frame of reference. We need not suspend our common sensibilities, our ordinary experiences. If the theory is truly complete and unified, it must be confirmed as much by our common experience as by mathematics incomprehensible to all but the few.

Hawking states the scope of science quite early in the book: "The eventual goal of science is to provide a single theory that describes the whole universe." (10) And he reiterates it even more strongly near the end: "Our goal is a complete *understanding* of the events around us, of our own existence." (169) And Hawking makes clear that he doesn't intend some limitations to the world of raw matter and energy when he writes: "If there really is a complete unified theory, it would also presumably determine our actions. And so the theory itself would determine the outcome of our search for it." (12)

These statements are philosophically astounding, a fountain of fascinating ponderables. As the frame shifts from a statement of the ambitious goals of science to the frame of an achieved complete and unified theory, there is a correlate shift in language. A metaphor for science in pursuit of knowledge is "theory is model." But when complete unity is achieved, this metaphor becomes "theory is entity." The relationship of human beings to theory is also inverted. Whereas in the pursuit of science, scientists construct theories, at the achieved goal, the theory determines the scientists' search. What odd transformations, though they can scarcely be avoided. A complete and unified theory must be inclusive and self-generating. Anything else would fall short of the goal of "describing the whole universe." It would seem that the theory, thus conceived, constitutes something of a singularity. The metaphoric language, "theory is entity," articulates its singularity. It is curious that in science's triumph over a theology of a God-created universe, the theory on which this victory depends takes on godlike characteristics of volition and control. The perplexing language that emerges as scientists contemplate the achievement of their goal reveals that the idea of a complete and unified theory is necessarily bound in paradox: it is a human conception, a mere model held in the mind, yet at the same time it is an entity that determines the very actions of its own generation, the actions of scientists.

Of course one is never without a frame of reference. At the widest we see according to a world picture we hold and, as Michael Polanyi has shown, much of that is tacit or hidden from us. Nonetheless, among the frames invoked by a complete and unified theory of the universe are the frame of scientific theory and the frame of human experience. The claim of completeness and unity demands that both frames, among perhaps all others, be held in play at the same time. Remarkably this simultaneous holding of multiple frames is a productive way of describing play, be it children's play, athletic contest, or theatre. Players abide by two or more frames *at the same time*. The interaction between coincident, yet irreconcilable, frames is what constitutes play. In discussing the implications of his theory, Hawking engages in a frame-shifting exercise artfully juggling such pairs as: the real and the imaginary, entropy and evolution, and order and disorder. Playfulness occurs in the identification of his theory as both model and entity. In his anthropology he considers the human mind to be a mere data recorder but, at the same time, he exemplifies the mind as capable of the thought required to construct a complete and unified theory of everything. There is play in Hawking's final and complete displacement of God as a creator by a theory that he proclaims allows him to "know the mind of God."(175) To gain the greatest insight into this aspect of Hawking's book it seems appropriate to consider it <u>sub specie ludi</u>, that is, as a species of play. In doing so we are led to conclude that the very idea of a grand theory of everything must be considered as either jest or riddle, perhaps both.

Even in the title of the book, *A Brief History of Time: From the Big Bang to Black Holes*, there is much evidence of Hawking's sense of the playfulness of his endeavor. Why a brief history of *time*? Why not a brief history of scientific cosmogony? Why not a brief reflection on the cosmos? Why brief? The subtitle implies that the book will provide a brief account of the history of the universe from its origin, but are "the big bang" and "black holes" the appropriate perimeters especially given Hawking's proposed view of a universe without boundaries? There are oddments here that must be thought about.

There are several dimensions of jest in the title. Likely the most obvious to all readers, even before reading the book, is formed by the incongruity between brevity and the span of cosmological time once so familiarly expressed by Carl Sagan's humorous trademark "billions and billions." Hawking prefers the nauseous repetition of the word "million" sometimes occupying lines of print . . . "million, million, million, million, million, million, million, million, million, million, million, million, million, ..." Upon encountering this display the first time, I said to myself, "Ha! and this guy calls this brief!" After another encounter I said, "who cares?" So we all get the first joke even without reading the book. But this sally is expanded and enriched by a thorough reading.

There is a subtle but profound play in the conjunction of "history" and "time." As Hawking uses the term, history describes a sequence of human development beginning in the past and terminating with himself in the present. It is linear and progressive. Time is the principal subject of this history. Hawking shows that human conceptions of time have undergone remarkable changes, especially since Newton. At the apex of this history, Hawking accounts for time in the terms of "imaginary" numbers in which time is indistinguishable from a dimension in space. From the perspective of mathematics there is no difference between going forward or backward in imaginary time. But Hawking uses his theory to show that the arrow of time, its direction, is determined by entropy, the propensity towards increasing disorder. By calling his book a history of time, Hawking playfully conjoins two conflicting temporal frames. "History" refers to the story of a time sequence of refinements and revisions in human conceptions that approaches ever more fully an understanding of the true nature of time. "Time" according to this achieved understanding is accountable mathematically only as "imaginary" yet has an arrow determined by entropy. "Time" is a measure of progressive chaos. The jest is: History is a kind of time that defies the conception of time that is itself a product of history.

The title plays in other ways on the same joke. The subtitle "From . . . to . . . " indicates that the big bang and black holes are the perimeters of the expanse of time. The understanding of the big bang and black holes depends on the idea of "singularity" (that point where the laws of physics break down). One of Hawking's remarkable insights was that where singularity exists, true unity cannot. His conception of a unified theory has been made possible to a major extent by his pursuit of a system that did not require a "singularity" at some terminating or originating point. For Hawking, there is really no beginning or ending to the universe, it simply is. "The universe . . . would neither be created nor destroyed. It would just BE."(136) Time is no more or less than a dimension of space. This jest is complex: In terms of the history of Hawking's development there was a progression beginning with his contemplation of the big bang singularity leading to his study of black holes in terms of singularities. But this really led him to reject the idea of singularity in favor of developing a quantum theory of gravity. In terms of the framing of time according to Hawking's theory there are no boundaries; there is no "from . . . to . . ." in Hawking's understanding of time.

The title exemplifies the dynamics of Hawking's frame-shifting play that can be discerned in many parts of the book. He defines one frame carefully in terms of scientific theory, then he plays it in the frame of human experience. In the resulting playful collisions we gain insight by being drawn into a labyrinth of jest and riddle.

The mathematics Hawking devises to carry out his theory development depends, he tells us, on his use of imaginary numbers, "special numbers that give negative numbers when multiplied by themselves."(134) But when these numbers reference the temporal dimensions of the universe, time is transformed into a coordinate. Since this dimension is measured by imaginary numbers, Hawking calls it "imaginary time." He reminds us that "imaginary time" and the resulting understanding of the cosmos is "just a proposal" as he describes how the world would look according to it, "time and space should be finite without boundaries."(136) He then contrasts it with the world of "real time:" "The history of the universe in real time, however, would look very different. . . . When one goes back to the real time in which we live, however, there will still appear to be singularities."(138-9)

Hawking plays back and forth between the frames of the imaginary time of his theory and the real time of our experience, something like shifting one's view of a diving pool from an underwater perspective to an above water perspective. This frame-shifting, back and forth, finally leads him to

> suggest that the so-called imaginary time is really the real time, and that what we call real time is just a figment of our imaginations. In real time, the universe has a beginning and an end at singularities that form a boundary to space-time and at which the laws of science break down. But in imaginary time, there are no singularities or boundaries. So maybe what we call imaginary time is really more basic, and what we call real is just an idea that we invent to help us describe what we think the universe is like.(139)

What a remarkably playful passage.

Hawking's play between imaginary and real time is rather like that bit of magic Woody Allen effects in his short story "The Kugelmass Episode"[3] in which the Great Persky, a two-bit magician, transports his client Sidney Kugelmass not simply into another time, but into a work of fiction set in another time. His trick takes Kugelmass, who believes he needs to have an affair, into Flaubert's *Madam Bovary*. Kugelmass insists that Persky send him to arrive before page 120 because he wants to "meet her before she

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[3] Woody Allen, "The Kugelmass Episode," *Side Effects* (New York: Ballantine Books, 1975), pp. 59-78.

hooks up with this Rodolphe character." Little does Kugelmass know that a literature teacher in Sioux Falls considers his students to be on drugs when they ask, "Who is this character on page 100? A bald Jew is kissing Madame Bovary?" The process even works in reverse allowing Kugelmass to bring Emma Bovary back with him to New York City, although Persky has some trouble getting her back. Hawking should take warning. She nearly breaks Kugelmass financially with her hotel bills, shopping sprees, and acting classes. Allen used the same device in the film "The Purple Rose of Cairo" where a character in a movie comes off the screen into real life and vice versa.

Imaginary time, indistinguishable from space, can be traversed in either direction. There is no difference between forward and backward in imaginary time, yet Hawking allows that "there is a major difference between forward and backward in real time"(144), that is in human experience. This leads Hawking to consider why time should seem to have a direction, an arrow, and why it should point in the direction it does. Hawking discusses what he understands to be the three basic arrows of time: the thermodynamic arrow of time which is pointed in the direction of the tendency for disorder to increase; the psychological arrow of time which is "the direction in which we feel time passes, the direction in which we remember the past but not the future;" (145) and the cosmological arrow of time which points in the direction in which the universe is expanding. Hawking sets out to argue that "the no boundary condition for the universe, together with the weak anthropic principle, can explain why all three arrows point in the same direction--and moreover, why a well-defined arrow of time should exist at all."(145)

Hawking's field of play is the frame-shifting between science where the second law of thermodynamics holds and human experience where his many examples indicate that it does not. The discussion of the direction of time constitutes the play. By conjoining these frames Hawking shows that they are wholly irreconcilable, yet somehow inseparable.

In Hawking's reckoning the thermodynamic arrow is fundamental and determines both the others. The second law of thermodynamics, the tendency toward disorder, is argued on the basis of there always being more disordered states possible than ordered ones. He points out that for a jigsaw puzzle there is but one arrangement in which the pieces make the picture (order), but there are many ways they may be jumbled (disorder). Beginning with a state of order, the puzzle worked, any disturbance of the puzzle will lead invariably to disorder. In a telling paragraph Hawking describes entropy:

> Suppose a system starts out in one of the small number of ordered states. As time goes by, the system will evolve according to the laws of science and its state will change. At a later time, it is more probable that the system will be in a disordered state than in an ordered one because there are more disordered states. Thus disorder will tend to increase with time if the system obeys an initial condition of high order.(146)

Hawking's understanding of order makes sense only when framed in scientific terms and it contrasts sharply with our human experience of order. If we were to proceed backward using the laws of science toward the beginning of the universe we would proceed towards singularity--a universe condensing toward a zero point in space and with temperatures rising toward infinity. I doubt that many of us would consider this a progression toward higher and higher order. In fact this heavy hot place resembles classical descriptions of Hell. We tend to think of order as structure and meaning. As the universe expanded stars formed, galaxies took shape, solar systems emerged with planets capable of supporting life. On at least one of these planets, life evolved to human intelligence. In this evolution, Stephen Hawking represents perhaps the highest level of intellectual advancement (I think he would agree with this evaluation). His book, *A Brief History*, tells the story of the progressive ordering of his thoughts on how to achieve a unified theory of physics, on how to comprehend black holes, on how to understand the nature of the universe. Still, Hawking plays in the frame where it is technically correct to hold that the achievement of this order produced more disordered energy in the form of heat than it produced ordered energy in the form of systems and intelligence. Hawking's own existence presents a frame-shift to the biological and intellectual arrows of time, which he curiously ignores. The directions of these arrows are determined by the evolution of species, by the cycles of growth and decay, by the advancement of knowledge and understanding. Hawking is a riddle to his own theory, if not an outright refutation of it.

There is something of a technical consideration of Hawking's correlation of time with the increase of disorder. In his description, quoted above, the sense of an increase in disorder appears to emerge because time exists as a frame of reference. The phrases "starts out," "as time goes by," and "at a later time" are crucial to the discernment that "disorder will tend to increase with time." In the logic of Hawking's argument, time is the base against which varying states of order are correlated. Against the passage of time disorder tends to increase. But Hawking had actually set out to demonstrate just the opposite, that increasing disorder is the base for the direction time points. The problem arises because Hawking has shifted frames again. He attempts to demonstrate the second law of thermodynamics, accepted in the domain of physics, in the world of human experience and ordinary language. Since he manages to demonstrate the opposite of what he says, the next phase of his argument is actually inverted as well. With the human sense of the passing of time standing as the base for the measure of increasing disorder, the psychological arrow is actually the base to the thermodynamic arrow rather than the other way around as Hawking claims. But this position hinges on the nature of memory. Hawking argues, playing at opposites, that the psychological arrow correlates with the thermodynamic arrow because it determines or feels time passing when the observed state of disorder is compared with the previous state of order (how previous is determined is another matter). He notes that a cup falling and breaking on the floor is remembered first as a whole cup and then as a broken cup, not the other way around. But surely this is based on the human conception of a cup which has a temporal aspect to it. It would be interesting to have Hawking argue this point on the basis of the puzzle example he uses, since, at least in my experience, the temporal aspect of the concept jigsaw puzzle would place the first memory of the puzzle as a jumble of pieces in a box. The passage of time correlates with the gradual appearance of order, the picture. Yet Hawking holds, "Disorder increases with time because we measure time in the direction in which disorder increases. You can't have a safer bet than that!"(147) Were this correct, the working of a puzzle and returning it to its box would take no time at all. Time would move backward from the jumble in the box to the working of the picture, then forward to the starting point when the picture is jumbled up and placed back in the box.

The discussion of the psychological arrow of time must include human memory. Hawking, admitting that the workings of the human brain are not well known, likens human memory faculties with the workings of a computer, holding at once that they are very similar and that he knows a good bit about how computers work. To add to the memory of a computer is to pass from a disordered state to an ordered one, but Hawking claims that doing this, along with checking to make sure it is correct, creates more disordered energy than it produces ordered energy. Hawking concludes this discussion with a most remarkable example:

> If you remember every word of this book, your memory will have recorded about two million pieces of information: the order in your brain will have increased by about two million units. However, while you have been reading the book, you will have converted at least a thousand calories of ordered energy, in the form of food, into disordered energy, in the form of heat that you lose to the air around you by convection and sweat. This will increase the disorder of

> the universe by about twenty million million million million units--or about ten million million million times the increase in order in your brain--and that's if you remember *everything* in this book. (152-3)

No place in the book is the double-framing more ludicrous than in Hawking's discussion of memory. His discussion of order and disorder can make sense only in terms of scientific theory, yet he shifts frames by discussing the functions of the human mind--reading and remembering. What does Hawking mean by order and disorder? In the frame where the memory is viewed as a recording machine, it seems that he understands order as pieces of sequentially stored recallable information somehow equivalent to units of energy. Though it really doesn't matter, he provides no clue as to how the storage of a single recallable piece of information is equal to the creation of a single unit of ordered energy. Nor does he tell us how he arrives at the figure two million. The book contains roughly 175 pages with 450 to 500 words per page. That would amount to less than 90,000 words and little more than half a million letters. That would mean that he measures on the average 20 to 25 pieces of information per word. Nor does he tell us how he determined that burning a thousand calories converts to twenty million million million million units of disordered energy. Though this makes me worry a little about the hundreds of other quantities he cites that we must also take on faith, the question really is: What is the significance, in terms of order in the human frame, of adding a piece of information (1/25th of a word) to recallable memory? Surely none, yet in doing so, shifting back to the frame of the second law, there is an increase in disorder by ten million million million fold and it is only that efficient if the unit of information is remembered!

Let's play a bit more, shifting back and forth between frames. In the area of human order, we might consider whether it makes any difference what I read? Is reading and remembering a cereal box equivalent to reading Hawking's *A Brief History*? Of course not. Shift. But according to the second law of thermodynamics it would be if we read the same amount of information. Shift. My brain does much work maintaining body systems, and therefore burns calories, whether or not I am reading. Likely the ratio of calories burned by my brain while not reading is about as much as while I am reading. Therefore, in terms of the contribution to entropy, it would seem to make little difference whether or not I read Hawking's book much less remember any of it. Shift. But it certainly does matter in the world of human order. Shift. Suppose that I read Hawking's book only on cold days. Now I can foil entropy by taking advantage of the heat produced by my brain to help heat my house. And lower my utility bill as well. The play goes on.

Jorge Borges wrote a wonderful story called "Funes the Memorious"[4] that may help us understand the playfulness of Hawking's image of the human mind as an information recording computer. The story may even reflect something of Hawking himself. Borges' character, Ireneo Funes, was known for his prodigious memory. As a boy he was familiarly known as "chronometrical Funes" because he might be counted on at any moment to know the exact time without having to consult a time piece. Thrown from a horse as a young man Funes was left hopelessly paralyzed. "He carried his pride to the point of acting as if the blow that had felled him was beneficial." His accident permitted him to become aware of the power of his memory. Borrowing a Latin book from a friend he learned Latin overnight. Such was the measure of his memory.

In conversation with his friend he expressed amazement that certain famous feats of memory should be considered prodigious. He recalled such examples as Cyrus, king of the Persians, who could call every one of his soldiers by name; Mithridates Eupator's mastery of the twenty-two languages spoken in his country, Simonides invention of the science of mnemonics, and Metrodorus's ability to repeat anything after hearing it only once. Funes could recall every moment of every day of his life with exactness. He had spent several days remembering specific days in his own past. Each day so spent required a whole day. He developed a system in which he reduced each day to seventy thousand memories each defined by means of ciphers.

His friend describes another of Ireneo's odd inventions.

> He told me that in 1886 he had invented an original system of numbering and that in a very few days he had gone beyond the twenty-four-thousand mark. He had not written it down, since anything he thought of once would never be lost to him. His first stimulus was, I think, his discomfort at the fact that the famous thirty-three gauchos of Uruguayan history should require two signs and two words, in place of a single word and a single sign. He then applied this absurd principle to the other numbers. In place of seven thousand thirteen, he would say (for example) Ma'ximo Pe'rez; in place of seven thousand fourteen, *The Railroad*; . . . Each word had a particular sign, a kind of mark; the last in the series were very complicated.

Funes's friend remarked of him "I don't know how many stars he could see in the sky."

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[4] In Jorge Louis Borges, *Labyrinth: Selected Stories & Other Writings*, D. A. Yates & J. E. Irby, eds. (Norfolk, Conn.: New Directions, 1962), pp. 59-66.

In Borges's character Funes we find an image that matches Hawking's description of the human mind developed to perfection. Funes's memory worked much like a computer, segmenting experience into memory units and assigning a cipher to each. Like a computer his memory was capable of perfect recall and it never forgot anything. Presumably the memory perfectly mirrored the experience.

Despite his memory capabilities, Funes suffered some difficulties. He told his friend, "My memory is like a garbage heap." His friend reflected on Funes's mind:

> The two projects I have indicated (an infinite vocabulary for the natural series of numbers, a useless mental catalogue of all the images of his memory) are senseless, but they betray a certain stammering grandeur. They permit us to glimpse or infer the nature of Funes' vertiginous world. He was, let us not forget, almost incapable of ideas of a general, Platonic sort. Not only was it difficult for him to comprehend that the generic symbol dog embraces so many unlike individuals of diverse size and form; it bothered him that the dog at three fourteen (seen from the side) should have the same name as the dog at three fifteen (seen from the front). His own face in the mirror, his own hands, surprised him every time he saw them. . . . With no effort, he had learned English, French, Portuguese and Latin. I suspect, however, that he was not very capable of thought. To think is to forget differences, generalize, make abstractions. In the teeming world of Funes, there were only details, almost immediate in their presence.

Funes is the man who can store and remember every word in every book that he has ever read. In Hawking's terms this is the man with the perfect memory, the man most efficient in creating order in the universe. Yet, thanks to Borges, we see that from the human perspective this is not the most meaningful kind of memory. Funes could not think, because he could not forget differences; he could not generalize or make abstractions. To think, especially to hypothesize, is to create order. Hawking himself is an exemplar of creative thinking; in creating the Grand Theory of Everything, he is the master at forgetting differences.

Again Hawking is a riddle to his own theory, as is human existence, which he acknowledges when he writes: "The progress of the human race in understanding the universe has established a small corner of order in an increasingly disordered universe."(152)

Time and again Hawking emphasizes the hypothetical nature of his theory. He describes what constitutes a theory and what is required to measure the "goodness" of a theory.

> Any physical theory is always provisional, in the sense that it is only a hypothesis: you can never prove it. . . . A good theory is characterized by the fact that it makes a number of predictions that could in principle be disproved or falsified by observation. (10)

This is standard stuff when applied to partial theories, but profound philosophical questions are posed when the theory in question claims to be complete and unified. Again it is a question of frames. A theory is a mental construct, as Hawking often reminds us. It exists only in the mind. What it describes, what it explains, is outside of the mind. Physics theories refer to the physical world. Theories explain aspects of the physical world. The explanations must be demonstrated by observation. But when the domain to which a theory applies is set at totality and proclaims unity, the basic structure of scientific validation is nullified. The phenomena explained must include the process of explanation and validation. The theory must explain the scientific method, the propensity of human beings to seek totality, and it must include the provision: this theory is false. In the construction and evaluation of theory there is a map-territory distinction that is arbitrated primarily by scientific method. This breaks down, creating a singularity, at the point the theory claims completeness. Here the theory becomes self-referential and the possibility of it being falsified by observation is nullified. The map is the territory; the territory is the map. The imaginary is real; the real is imaginary.

Hawking addresses this issue very early in the book when, using the metaphoric construct "theory is entity," he asks:

> Why should it [the theory] determine that we come to the right conclusions from the evidence? Might it not equally well determine that we draw the wrong conclusion? Or no conclusion at all? (12)

Hawking appeals to the domain of evolution, the area most confounding to his theories, to propose an answer, although I think his understanding of evolution differs from most because he seems to think it applies to individuals.

> Based on Darwin's principle of natural selection . . . some individuals are better able than others to draw the right conclusions about the world around them and to act accordingly.(12)

At the attained goal of science, the "theory is entity" metaphor calls for a transformation in theory evaluation. The preservation of entropy in Hawking's theory stands in contrast to the principle of evolution, still the theory cannot exist without the human theorizer who has evolved through natural selection to construct the right theory. The implication seems to be that a complete confirmed unified theory has an identity with the reality to which it refers. This is like having a map that is a perfect replica of the territory. A traveler would have no way of distinguishing whether s/he was on the map or the territory. But ironically a wrong map would give the same impression. At its fullest achievement theorization eliminates singularity from scientific theory, but at that point singularity appears to be reintroduced philosophically. When the map is indistinguishable from the territory, the theory from the reality, the imaginary from the real, and right from wrong, there is the sort of absurdity that theories of science isolate and call singularity.

Confronted with limiting conditions, at the point where law and principle face absurdity, in the moment when rationality becomes impotent, human beings often tend to find insight, wisdom, energy, motivation, pleasure, and joy. The human mind and spirit are capable of not only holding two irreconcilables, but finding meaning in their coincidence. Philosophy deals with such apparent singularities in the terms of paradox and dialectic. More broadly, humans recognize these as the grist for the mills of play and comedy.[5]

Hear the comedian Steven Wright:

> "I want to get a tattoo of myself . . . life size . . . only bigger."

And Lewis Carol:

> "What do you consider the largest map that would be really useful?"
>
> "About six inches to the mile."
>
> "Only *six inches*!" exclaimed Mein Herr. "We very soon got to six *yards* to the mile. Then we tried a *hundred* yards to the mile. And then came the grandest

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[5] In a delightful imaginary conversation with a military general, Charles S. Peirce defends the importance of a system of diagrammatization by likening diagrams to military maps. No matter how well the terrain of a battle is known to a General, he will still demand a map "to stick pins into." See *Collected Papers of Charles Sanders Peirce* edited by Charles Harthshorne and Paul Weiss (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1931-1958), 4.530.

> idea of all! We actually made a map of the country on the scale of *a mile to the mile*!"
>
> "Have you used it much?" I enquired.
>
> "It has never been spread out, yet," said Mein Herr: "The farmers objected: they said it would cover the whole country and shut out the sunlight! So we now use the country itself, as its own map, and I assure you it does nearly as well."[6]

Engaged by the meaningless absurdity of singularity in scientific theory Stephen Hawking devises a complete unified theory. But it is really a construct which holds multiple irreconcilables at once. This is what must be done in order to unify quantum mechanics and classical relativity theory. The result is a play theory of cosmology. Hawking exposes the fullest measure of its absurdity by playing it to the tune of human experience. But here there is significance. He shows that, at its goal, science becomes an endeavor of the ludicrous, an activity of laughter and play, among the freest and most creative of human activities.

Hawking holds that one must be able to use a theory to make predictions that in principal are falsifiable by observation. On philosophical grounds making predictions with the complete unified theory is impossible. Hawking, however, proceeds in the usual way of making predictions effectively conjoining the irreconcilables: "theory is model" and "theory is entity."

> Even if we do discover a complete unified theory, it would not mean that we would be able to predict events in general, for two reasons. The first is the limitation that the uncertainty principle of quantum mechanics sets on our powers of prediction. There is nothing we can do about that. In practice, however, this first limitation is less restrictive then the second one. It arises from the fact that we could not solve the equations of the theory exactly, except in very simple situations. (We cannot even solve exactly for the motion of three bodies in Newton's theory of gravity, and the difficulty increases with the number of bodies and the complexity of the theory.) (168)

If the complete unified theory cannot make predictions, it is incapable of being falsified,

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6 Lewis Carol [Charles Dodgson], "Sylvie and Bruno Concluded" (London: Macmillan, 1893), p. 169.

and technically is not a scientific theory. Though, of course, this conclusion holds only under the metaphor "theory is model."

Hawking places his comment about calculations in parentheses, sort of an aside, as though sooner or later we will acquire the computational powers or skills needed to make these calculations. But in the late nineteenth century Henri Poincaré showed that it is impossible to compute explicitly the general solution of the three-body problem. This stems from the fact that the value of functions (π for example) needed to calculate positions and velocities are not exact but are unending divergent series. Expressed as decimal fractions there is no decimal place at which the value becomes exact. For practical purposes these functions are given a set value. But in a dynamic system the influence of even the smallest variance is eventually felt and often sooner than later.

In the 1950s Edward Lorenz modeled weather patterns by computer simulation. Using several simple differential equations he ran simulations from various initial values. In rerunning one simulation he restarted the computer entering values from an earlier computer output. After simulating a two-month weather pattern Lorenz was stunned to find that the second simulation did not even resemble the first, yet he believed that he was simply redoing the simulation using the same equations and values. He was finally able to trace the difference to the fact that the computer used values to six decimal places in calculation, yet when he repeated the simulation he entered only the first three digits, unwittingly dropping the last three. In a remarkably short span these small differences, smaller than one thousandth of a unit, accounted for a completely different weather pattern. This finding has had enormous impact on mathematics and science. Lorenz called it the "butterfly effect" suggesting that the flight of a butterfly could create sufficient perturbance that in time might result in a major weather event. He estimated that small perturbations are multiplied by four every week and by three hundred every month. This also explains why weather is so difficult to forecast.

But earth's weather is a simple system when compared with the interacting bodies in our galaxy or in the universe or in our brains and bodies. Hawking acknowledges that the difficulties in calculation are even more restrictive on his theory than the limitations set by the uncertainty principle of quantum mechanics, but he doesn't say enough. Though Hawking acknowledges the impact of the uncertainty principle on LaPlace's determinism, he continues to use a somewhat qualified deterministic strategy that informs many of his assumptions. The implications of the issue of calculation present more than qualifications to determinism, they end determinism altogether.

Such an end brings time into play in an unexpected way. In a deterministic theory, such as Hawking's, time, at least in one sense, is essentially eliminated, killed. That is the effect when one holds that given the state of the system at any one point in time, the state of the system at all other points in time can be calculated. Deterministic theories spatialize time, making it a space-like coordinate in the system. Hawking has taken this further than any others. Yet, in human experience, as Hawking shows, time rarely resembles the predictability of space. It is non-homogeneous, ever changing, often unpredictable, and sometimes totally enigmatic. The reintroduction of time into science and mathematics has proceeded full tilt. Interest in "chaos" among scientists is widespread, although it is really interest in how order emerges from apparent randomness rather than a true interest in chaos. Determinism dies hard. The mathematics of René Thom, unfortunately called "catastrophe theory" (I prefer to call it "surprise theory") is similarly based. Through these areas time is being reborn in the sciences.

What happens to the keystone of scientific objectivity at the point of a totalization theory? Again, Hawking provides insight. His discussion of what is really real, imaginary time or real time, concludes with the following telling observation:

> a scientific theory is just a mathematical model we make to describe our observations: it exists only in our minds. So it is meaningless to ask: Which is real, "real" or "imaginary" time? It is simply a matter of which is the more useful description. (139)

Adding to the language of goodness, and right and wrong in the evaluation of theory, Hawking introduces "useful." There is little question that the coherence of the theory underlies the scale of usefulness. If the theory coheres by considering imaginary time to be real, then it is real time. The decision rests with the creator of the theory, the judge of usefulness. The creator of the theory must also be that person who, through the processes of natural selection, has become "better able than others to draw the right conclusions about the world around them and to act accordingly."(12) Who else could it be? How can scientific objectivity be preserved? At the limiting conditions, in the philosophical singularity, the object of the theory is coincident with the theory itself. The only frame potentially larger is the mind in which the theory is created, although it too must be explained by the theory. Only from the perspective of this one mind can the theory and the coincident world be considered as an object. Therefore, the purely subjective measure of the theorist is the equivalent of scientific objectivity.

Hawking begins *A Brief History* by recounting a story about turtles. It seems that "a little old lady," I believe in the versions I have heard of this story the woman is Iroquois, informed a scientist who had given a lecture on astronomy, that what he said was rubbish proclaiming that "The world is really a flat plate supported on the back of a giant tortoise." The scientist retorted by asking "What is the tortoise standing on?" To which the lady replied "You're very clever, young man, very clever. But it's turtles all the way down."

Hawking noted that "most people would find the picture of our universe as an infinite tower of tortoises rather ridiculous, but why do we think we know better?" This is a very good question. Hawking returns to it in his conclusion when he says that, faced with living in a bewildering world, human beings respond to the questions it raises by adopting some "world picture." Then he compares the tortoise tower to string theory, an imaginative endeavor of physics.

> Just as an infinite tower of tortoises supporting the flat earth is such a picture, so is the theory of superstrings. Both are theories of the universe, though the latter is much more mathematical and precise than the former. Both theories lack observational evidence; no one has ever seen a giant tortoise with the earth on its back, but then, no one has seen a superstring either. However, the tortoise theory fails to be a good scientific theory because it predicts that people should be able to fall off the edge of the world. This has not been found to agree with experience, unless that turns out to be the explanation for the people who are supposed to have disappeared in the Bermuda Triangle. (171)

But as he does so often, Hawking shifts frames. The stories of the tortoise cosmology are common in cultures the world over. They are not advanced with any intention of predicting anything in the terms of the raw physicality of the world. These stories depict the universe as purposeful and as supported by a dependable sentient being. Hawking shows the ludicrousness of science by treating the tortoise story as a theory that predicts that people should be able to fall off the edge of the world. Were the holder of the tortoise story to shift frames to science, she could proclaim that the flat plate supported on the back of the turtle is virtually infinite in size; that at its hypothetic edge the laws don't hold; what appears as the edge is a singularity. She might also demand a bit of evidence for those wild stories Hawking tells of astronauts being stretched like spaghetti upon falling into black holes. But this is not the point. While the tower of tortoises, superstrings, and the finite world without boundaries cannot all be considered scientific theories, indeed perhaps none is truly legitimate, all can be successfully considered as stories, products of human thought and creative imagination motivated by the desire to create order and meaning.

Whereas the core of Stephen Hawking's book is a description of the development of modern cosmology and, in particular, his own theory development, the book is more fully appreciated when seen as a playful exploration of the nature and limitations of science and human imagination. Hawking boldly engages the human world with the assumption that it ought to be explained by a complete and unified scientific theory. Taking this seriously he jerks us back and forth in the play between the realms of scientific theory and human experience. In his every analysis, Hawking, as exemplar of creative and imaginative human thought, turns out to be a riddle not only to his own theory, but to the stated goals of science. Riddles are not to be resolved. They are to be thought, indwelt, and experienced. Riddles are interrogative metaphors that open us to insights that are otherwise inaccessible. We come to know more about ourselves and our world from the play of riddles.

Hawking reminds us of the wisdom we already hold about the Grail we pursue in so many avenues of life. By daring to grasp the goblet he exposes the nature of its power. It's strength lies in its being pursued; it would be powerless if ever attained. As Jacques Derrida wrote:

> If totalization no longer has any meaning, it is not because the infinity of a field cannot be covered by a finite glance or a finite discourse, but because the nature of the field--that is, language and a finite language--excludes totalization. This field is in fact that of freeplay, that is to say, a field of infinite substitutions in the closure of a finite ensemble. This field permits these infinite substitutions only because . . . there is something missing from it: a center which arrests and founds the freeplay of substitutions.[7]

Hawking's idea of "a finite world without boundaries" applies well to language--"a field of infinite substitutions in the closure of a finite ensemble"--and to being human. Hawking repelled by the meaningless absurdity of the singularity that inevitably arises in the pursuit of centers, origins, and goals, points us in the direction of grasping the meaningful absurdity that arises in the realization that there is no center, no total theory, only play, freeplay.

But I have been playing with Hawking's words, and he ridicules such play through the

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[7] Jacques Derrida, "Structure, Sign, and Play in the Discourse of the Human Sciences," in *The Languages of Criticism and the Sciences of Man*, Richard Macksey and Euginio Donato, editors (Baltimore: The Johns Hopkins Press, 1970), p. 260.

juxtaposition of science and philosophy:

> In the eighteenth century, philosophers considered the whole of human knowledge, including science, to be their field and discussed questions such as: Did the universe have a beginning? However, in the nineteenth and twentieth centuries, science became too technical and mathematical for the philosophers, or anyone else except a few specialists. Philosophers reduced the scope of their inquiries so much that Wittgenstein, the most famous philosopher of this century, said, "The sole remaining task of philosophy is the analysis of language." What a comedown from the great tradition of philosophy from Aristotle to Kant. (174-5)

What I have written about Stephen Hawking and *A Brief History of Time* are mere words, written on paper but born from the mind, a selection of quotations, the construction of incongruous juxtapositions, a concoction of positions, an imagination of motivations, a proposition of ideas, the forging of an absurd non-resolution. Nothing but a play on words.