CHAPTER 17

EXTRAPOLATIONS AND SPECULATIONS

You shall not be required to finish the work, but neither are you free to desist from it.
Rabbi Tarfon: Ethics of the Fathers, 2:15, circa 70 C.E.

This chapter of speculation should be regard as an intellectual dessert (French, *desservir*, to clear the table). Like a dessert, it should never, ever be eaten before the main course. Like a dessert, it should not be partaken of by those with restricted diets. Like a dessert, it should be digested in a relaxed and unhurried fashion, with the mind at ease and the body at rest. Like a dessert, it should be eaten sparingly and should confer a degree of joy.

REALITY

The first portion of this book was largely devoted to the study of the mathematical capabilities of the $F = kH$ equation, and the second portion was directed towards the philosophical underpinnings of the theory which gave rise to the equations. The material was presented, chronologically, backwards, since it was the idealist world view, the concept of the relativity of perception, which, in my mind, gave rise in the first place to the mathematical theory. I chose this chronological reversal because, as mentioned, I retain a view of my more typical reader as one who would rather study the science before the philosophy. The extent to which we have deviated from Marr's philosophy (Chapter 1) should be clearly appreciated. We do, indeed, examine the "validity"[1] of what the senses tell us; we do not, strictly speaking, regard the senses as telling us "what is there"; and we have, certainly, toiled with the "molecules of perception." We have worked only with percepts of the simplest kind: steady stimuli of the "intensity" type, leaving much of the world of sensation and perception yet to be explored with the new H-concept.

Beginning with a somewhat restricted form of Berkeley's philosophy of perception, we have mapped the Berkeleian world view onto the anatomical-physiological elements of a hypothesized perceptual unit, so that the perceptual unit becomes an organ for the enactment or realization of this subjective world view. Most people are quite happy with the objective world of science that has sufficed for many centuries. What can we make of a world which is relative to you, and concurrently, to me? Is your "outside" world the same as mine? In what sense is the outside world unique or "real"? As we combine our subjective molecular percepts, how do our minds produce cohesive models of the external world? For example, how does the bright stimulus + hard stimulus + cold stimulus unite in our minds to produce, say, an ice-cube? This question has, of course, been asked many times. Of fundamental importance is the extent to which the external world may be said to exist relative to the *community of perceivers* rather than relative to each individual mind or perceiver. Berkeley seemed just to assume that the universe could exist relative to a collective mind (yours or mine or both); but on a physiological scale, how does my perceptual unit allow for your perceptual unit?

If we utilize $F = kH(I, t)$ purely as a mathematical entity, without querying its philosophical base (as some of my colleagues encourage), we emerge with a functional, predictive system, and even one that confers a degree of unity within sensory science and among the respective sciences (remember the unifying property of $PV = RT$). The problem arises when we ask ourselves about the *reality* of the world that underlies the $F = kH$ relation (remember how the derivation of $PV = RT$ supported the molecular theory of matter). Our problem, here, is very similar to that currently facing quantum mechanicians. Quantum mechanics provides the mathematical machinery for calculating what is observed, and the machinery works flawlessly. However, when we inquire what the equations of quantum mechanics *mean*, the answers are not so readily forthcoming. We are led to ask a very fundamental question about the nature of science: Is the job of the mathematical sciences primarily one of prediction – of striking a set of operational equations that produce verifiable results? Or is the aim of science to "understand" what these equations mean and to grasp the essence of reality?

THE PERCEPTUAL UNIT

Slowly, slowly, we have been formulating the nature of this unit, the smallest structure capable, *in itself*, of perceiving or being aware. We shall not be capable of completing the formulation, but we must not refrain from trying. It is the stopped buck. It, in itself, is what perception is all about. The onus of creating awareness may not devolve upon some remote and unreachable cerebral structure, nor may we assume it to "emerge" somehow from the interaction of a myriad of simple, unperceiving elements.

If we assume the attitude that the mathematical equation constitutes the ultimate scientific reality, then we may reduce the perceptual unit to its simplest form. It may consist solely of a receptor-neuron complex. The neuron transmits impulses at rate, F, in proportion to an H-function that begins at its maximum and decreases progressively with time. When the current stimulus terminates, natural processes built into the receptor reset the variable m or t back to zero, perhaps even by digital processes. The receptor "sleeps." When a new stimulus arrives, the receptor "awakens," H again assumes its maximum value, and the process repeats.

However, if we take the attitude that the H-function represents something real, and that changes in the magnitude of H represent changes in that reality, the perceptual unit becomes less simple. We have interpreted the quantity, H, as a measure of uncertainty. With this real interpretation of H, the perceptual unit which assumes the value, H, is most uncertain near the beginning of the act of perceiving, and becomes less uncertain as the act proceeds. We have seen in the previous chapter how the magnitude of the perceptual unit's uncertainty can be self-instilled by means of self-generated stimuli or extramission – that is stimuli produced by the perceptual unit it*self*. The key word is *self*. *I* am only uncertain if *I* know of multiple possibilities. So the element omitted from our discussion in Chapter 16 is the element of self. How can the perceptual unit determine that the extramitted stimulus does arise from within itself?[2] Much is written about the identification of structural self immunologically, but little is written about the identification of sensorineural self. I suggested (Norwich, 1983) that the self-generated signal might be identified by its cyclicity. That is, if the perceptual unit were fabricated as a closed loop, then a signal generated at some point, P, in the closed loop would initiate a self-generated signal, whose neurological report would return to the same point, P. The time that elapsed between the initiation of the signal and the neurological report would identify the stimulus as probably of origin within the self.

Must the external and internal stimuli arrive nearly simultaneously, as in the photon example of Chapter 14, or is there a local perceptual-unit-memory, so that there is recall of internal stimuli of the past?

The proof of the pudding may be in the creating. Can we construct a model – an analog rather than a computer model[3] — of a system with active and passive elements (externally and internally generated stimuli)? Such a hardware-model should also produce its H-function by analog means. That is, some physical process (not a digital calculation) should have H as its output. I have been searching for such a model, particularly by looking at the analogy between H and S (Chapter 15), because free energy is a function of S and it is the free energy that will empower the analog model.

Would such a model of the perceptual unit, if it were created, be capable of perception or awareness on some rudimentary level? We lack a test for "awareness" analogous to the Turing test for machine thinking. In any case, we could not interrogate a single perceptual unit to determine its state of mind. It would be difficult or impossible to determine whether a primordial perceptual unit, capable, say, of perceiving lights of different intensities, were aware in some way. The unit will require a motor component to allow it to effect a response before one could seriously consider a test of awareness.

I am also concerned about the lack of an element of *motivation* in the hypothesized perceptual unit. At the simplest level, the motivation to perceive is to obtain pleasure or to avoid pain. Yet we have discovered no elements within our model of perception that could be identified with pleasure-pain. Is there a component in the mathematical model that has been overlooked? Is the theoretical structure of the perceptual unit not yet rich enough? Do pleasure-pain emerge only when we consider groups or networks of perceptual units?

The entropy theory is a bottom-up theory. That is, we are trying to comprehend higher perceptual functions by building upon a fundamental, complex perceptual unit. We have not engaged in neural networking, in which very simple, axon-synapse-dendrite processes operate in great numbers to produce "emergent" effects that, it is hoped, will explain higher cognitive processes. In the entropy approach, the core of awareness lies in one, discrete structure; in the current networking approach awareness may emerge from the interaction of many unaware components. There is a clear difference in philosophy between the two approaches.

ILLUSIONS: THE NECKER CUBE AS ENTROPIC MULTIVIBRATOR

A feature of this chapter on extrapolations is that we finally break the fetters that bound us to elemental stimuli of the intensity type, to consider the principle of entropic perception applied at higher and higher levels: perception of speech, perception of other creatures, perception of the laws of physics.

We did make mention earlier of the Troxler effect, whereby an image which is held to a constant position on the retina will appear to fade out. This phenomenon may be an example of the adaptation principle – decrease to zero of the H-function for a whole image – with consequent reduction of F to zero. In other words, we can perceive an image as long as some uncertainty about its nature or quality remains. However, when all information has been extracted, the image fades. One cannot perceive a certainty.

One might also consider the type of fine eye movements called *micro-saccades*. Even when a subject tries to keep his eyes as still as possible, small movements of the extraocular muscles occur every second or so and tend to shift his gaze by 5 -10 minutes of arc. Do these eye movements function as the discouragers of certainty, guaranteeing a continually changing retinal image in order to prevent a Troxler fade-out?

It is interesting, in this regard to consider illusions of the Necker cube type (Figure 17.1). The three-dimensional interpretation of this drawing by a viewer tends to shift between two alternatives: A-face front or B-face front. There is a very simple explanation for this phenomenon within the entropy theory. We perceive one three-dimensional interpretation until little uncertainty remains: for example, the A-face is forward without much doubt. But "without much doubt" suggests that the image will be destroyed, because we cannot perceive a certainty. Thence, the second three-dimensional interpretation supervenes. But when the B-face is forward without much doubt, the first interpretation, which has de-adapted somewhat, supervenes, and so on: an entropic multivibrator. Adaptation, in this process, need not proceed to extinction as in the Troxler effect.

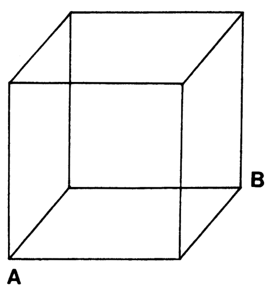

Figure 17.1 The Necker cube. Face A and face B will alternately appear to be closer to the viewer in three-dimensional space as he or she regards the two-dimensional projection. A very simple explanation for this phenomenon in terms of the entropy theory is suggested in the text.

COCHLEAR IMPLANTS

These cochlear prostheses have been developed during the past 25 years as an aid for the deaf (e.g. Gulick *et al.*, 1989). They consist of a small microphone similar to those found in hearing aids. The output voltage of the microphone is led to a processor, whose output, in turn, is transmitted to small wires beneath the skin, just behind the pinna of the ear. These wires carry electrical signals through the middle ear to the cochlea, where a small piece of metal serves as a stimulating electrode. Current from this electrode passes through the cochlea and excites some of the residual auditory nerve fibers, and returns through a ground electrode. There are many types of cochlear implants (extracochlear, intracochlear, single channel and multiple channel). It is significant that these implants *do* help many people perceive sound. In some cases, the patient will experience only a nondescript sound, which may, nonetheless, serve as a warning of danger. In some cases, speech perception is actually improved somewhat.

However, armed with the concepts of the entropy theory of perception, and fortified by the idea of the perceptual unit which embraces both active and passive elements, we are led to suspect that the current cochlear prostheses contain only half the number of elements needed for true auditory perception. The cochlear implants contain the passive elements of the perceptual unit, but not the active elements. To be truly effective in aiding sound perception, a cochlear prosthesis must be able to generate sound as well as to receive it. This is a tall order, and it is not clear how to implement it. Are there efferent neurons (those leading from the brain towards the ear) that might serve to activate a source of low intensity sound, and so complete the perceptual unit? I wonder.

THE RELATIVITY OF EXISTENCE

If *esse* is *percipi* – to be is to be perceived – and if perception is relative, then it would seem that "existence" is relative as well. The world exists relative to the perceiving organism. We have been flirting with this theme throughout the past few chapters, but let us pick up the thread again.

The earthworm possesses a rather rudimentary nervous system by mammalian standards. Its perceptual system seems quite capable of maintaining the earthworm in the habitat in which it lives: the ground. If I asked the question "Is the earthworm aware of, or conscious of the existence of the planet Mars?" I should probably receive, nearly universally, a reply to the negative.[4] Earthworms just don't know anything about Mars. They cannot see the planet; they cannot touch it. And no matter how many hours I spend trying to teach the worm about the existence of this planet, whose reddish corpus I see clearly hovering above me, the worm will not (likely) become the wiser. There is nothing in the structure of the worm's nervous system that would convince us human beings that it could ever be conscious or aware of the existence of the planet Mars.

However, I would argue that the previous sentence does not go far enough. If Mars is not perceivable by the earthworm, then *Mars does not exist with respect to the earthworm.* The universe that exists relative to the earthworm does not extend beyond the matrix of soil which it makes its habitat, and does not include Mars.

Well, what's the difference really, you must be asking, between the two statements:

(i) The worm cannot be aware of the existence of Mars,

and

(ii) Mars does not exist with respect to or relative to the worm?

Purely semantics, you may say.

There is a difference, however (although vermiform readers may declare the whole question non-existent). Statement (i) is part of the classical world view of an objective universe. I look up in the sky and see Mars; I look down in the earth and see the worm. Both Mars and the worm exist in an absolute sense; the worm just doesn't know about Mars. Statement (ii) is made within a system of relative existence. Mars and the worm both exist with respect to me, but Mars does not exist with respect to the worm. The fundamental views of science are different, and the consequences of these views are different. To wit, consider the theory of evolution.

THE EVOLUTION OF EVOLUTION

By the *theory of evolution* I shall mean the totality of the hypothesized process whereby the universe expanded, perhaps from a big bang that occurred at a single "point in space",[5] to form galaxies of stars, the planet earth, early forms of animal life, and finally(?) the human species. The first component is often referred to as *physical evolution* and the second as *organic* or *biological evolution*. The Big Bang is still our Best Bet as the beginning of the process of physical evolution, and natural selection provides a simple, easily visualized mechanism for biological evolution. The problem with this classical theory of evolution, from big bang to *Homo sapiens*, is that the process of evolution is presumed to occur within the framework of an absolutely existing universe, not a relatively existing universe. What meaning can be assigned, within a relative world view, to the existence of the universe in its early evolutionary form before the emergence of creatures that were capable of perceiving it? If existence is relative to a perceiver, what meaning can be ascribed to a physical process (for example, stellar evolution) that occurred before the emergence of the perceiver?

What line of reasoning led to the conceptualization of the big bang theory? Simply that observation of the motions of the galaxies showed that each galaxy was receding from all others. From knowledge of their present locations and present velocities, one can *extrapolate* backwards in time to show that an approximately determinable epoch, some 10 – 20 billion years ago (where one billion is taken as 1000 million), all the matter in these galaxies occupied the same "point in space."[5]

There is some additional evidence to support the big bang theory. If the matter that existed in the early moments following the big bang were partially in the form of radiation,[6] then, it was deduced, this radiation should still be present, disseminated throughout the universe, and should be largely in the microwave region of the electromagnetic spectrum. In simple language, all around us there should be microwave radiation that does not emanate from leaky microwave ovens, or from police speed traps, but which issued from the big bang. This prediction was made in 1948 by R. Alpher and R. Herman based on theoretical studies they had made earlier with George Gamow (see, for example, Weinberg, 1979, or Narlikar, 1977). In fact, in 1965, isotropic radiation in the microwave region was detected by A. Penzias and R. Wilson of the Bell Telephone Laboratory. Thus there is some confirmatory evidence in support of the big bang hypothesis.

Therefore, there are two channels of evidence that the universe preceded, by aeons, the advent of intelligent perceivers.

By way of analogy, suppose you arrive at an auditorium for a meeting to find the assembly on its feet singing the 7th line of the national anthem. You reason that you arrived after the meeting had been called to order and that the first 6 lines had been sung before you arrived. But you are not absolutely sure. The assembly may have risen to its feet the instant you arrived and begun singing the anthem at line 7 (the chorus) in order to expedite the proceedings. However, you recall that the meeting was to have begun at 8 o'clock, and you arrived at 8:01. There was just time between 8:00 and 8:01 for the assembly to have risen and sung the first 6 lines of the anthem. The dual lines of reasoning tend to convince you that the proceedings were afoot when you arrived. While you were ruminating about such trivia, you managed to miss the first item of business.

In 1992, a third channel of evidence in support of the big bang was reported by the COBE (Cosmic Background Explorer) group in the U.S. in the form of angular anisotropy in the background radiation that may have allowed for formation of galaxy clusters under influence of gravitational forces.

In summary, then, there is evidence that systematic cosmological activity occurred prior to the emergence of percipient beings. That is, we can extrapolate our current model of the universe backwards in time to obtain a consistent picture of prehistory. We cannot, however, formulate any model of the universe that existed more than 20 billion years ago, "before" the big bang. The theory of relativity teaches us that time, itself, cannot be measured through a singularity such as the hypothesized primordial explosion. Equations break down as certain quantities tend to zero or infinity, and no meaning can be assigned to "time" before the big bang. So, while some evidence supports a universe that preexists the perceiver, this preexistence is not of infinite duration. Cosmologically, it *may be*[7] possible to project into the future by times orders of magnitude greater than we can project into the past. Perhaps 15 billion years is the epoch of (or the "now" of) perception.

However, there are other dimensions to this problem of extrapolation backwards in time. We have assumed that laws of physics formulated by modern man preexisted him. Thus we have assumed, for example, the validity of general relativity as a theory of gravitation (or Newton's law of gravitation) acting on the receding galaxies, of the uniqueness of Planck's constant etc., prior to the emergence of the organisms who were first capable of formulating them. The big bang hypothesis is a consequence of the conjecture that the laws of nature are independent of the beings who were first capable of perceiving these laws. However, do the laws of physics themselves change with the emergence of man?

Let us consider Darwinian or organic evolution, which is believed to have occurred during at least the past 3.4 billion years.[8] A process of natural selection, operating to select random mutations that were favored to survive in their environment, is believed to be responsible for transforming very elementary life forms, progressively, into present complex forms, including man. Indisputably, it is a marvelous theory, *but is Darwinian evolution a complex enough theory to survive in the environment of perceptual relativity*, *or must the theory*, *like its elements*, *evolve to produce higher forms*?

I remind my faithful reader that what I present now is, as the chapter title promises, purely speculation.

We recall that within the entropy theory there are two phases: an active and a passive phase. The active phase serves to establish uncertainty and the passive phase to remove it. The active phase asks a question about the perceived world, and the passive phase answers this question. While we have developed this theory within the bounds of elementary sensory experience, I propose that we now generalize it to include perception of the world at all levels of complexity. The perceptual process is, then, one of formulating questions and obtaining answers to these questions. However, there is not much purchase in enunciating a principle in this somewhat weakened form, so I propose a stronger and more Audacious Formulation (AF):

If an organism lacks the capability to pose a (*well-formulated*) *question about some feature of a world*, *that feature of its world cannot exist relative to this organism.*

This generalization issues by induction (warranted or unwarranted) from the simpler cases of sensory perception that we have analyzed mathematically. The word "feature" that appears in the AF is not crisply defined, nor is the term "well-formulated," so that this preliminary formulation is not adequate, in itself, for the construction of a mathematical model. The interrogative or questioning element of the process of sensation consisted (in its analog form) of the generation of signals such as light or sound. The assertive phase consisted of finding these signals in the world of the perceiving organism. Within the simpler sensory context, then, the AF above in italics states that if an organism cannot, itself, generate light signals (interrogative), its immediate sensory world cannot contain light-generating elements (assertive). Even simpler, if an organism is lacking in solid elements (interrogative), its relative world will be found to be lacking in solid elements (Chapter 16). The AF is a generalization of these simpler, purely sensory functions, that we have analyzed previously.

It has often been observed that we learn about an age (historically) or about a people (anthropologically) from the questions they ask. However, the AF goes much further.

Einstein expressed his amazement that the world was intelligible at all.[9] The AF responds to this amazement by making intelligibility a precondition for existence of the world in the first place.[10]

We have substituted the term *intelligibility* for the phrase *the ability to pose a* (*well-formulated*) *question*, which appeared in the AF, and for the active, interrogative, or uncertainty-generating phase of perception. But remember the kinship that we established between the words *intelligible* and *perceivable* in Chapter 2: both words imply the fashioning of a set of alternatives, and the choosing between (*inter-lego*) these alternatives. The English adjectives *intelligible* and *perceivable* represent scientifically related concepts.

We have also shifted from considerations of existence relative to an individual to consideration of *existence relative to a species*.

By the AF, the world exists relative to us with characteristic features (such as the laws of physics) because we have been able to interrogate it with respect to these features. Note that the AF has been formulated in such a way that it is the *capability* (in the physiological sense) to interrogate the world about some feature, such as a law of nature, that determines the existence of this feature. Thus, we do not expect that the laws of nature would change relative to *Homo sapiens* during the floruit of this seemingly stable species. The postulated relatively existing universe is subjective insofar as it depends for its existence on the perceiver, but it still retains a degree of objectivity since the perceiver cannot fabricate the world at his whim. Stated another way, the world of the perceiver may contain only those elements which (s)he can interrogate, but *which* of these elements will be found to characterize the world is not under control of the perceiver.

The AF was suggested in order to codify, albeit in a preliminary way, the concept that the world as we know it cannot exist relative to a creature of differing "intelligence" which is not capable of questioning it in the manner that we are. Thus, again, Mars, as an orbiting planet, does not even exist relative to the ape (and *a fortiori* to the earthworm), who cannot interrogate its trajectory in the heavens.

One could say, also, that the earthworm has an existence relative to the human perceiver, but the human being has no existence relative to the earthworm, as distinct, say, from a rock or other impediment to its movement. However, I do not favor such a statement because it seems to give the human being preferred status with respect to the worm. Putting chauvinism aside, I prefer to say that each percipient creature can exist within the world of another, in some fashion.

How can one envisage "parallel" worlds for two creatures who perceive at different levels? Visualization may not be possible, but perhaps we may approach the matter by analogy. Suppose that somewhere within our 3-dimensional world there exists a world of 2-dimensional creatures who are confined forever to life in a (2-dimensional) surface (Figure 17.2). These creatures have positively no concept of a third dimension, living out their whole lives confined to a surface having length and height, but no depth. We can read about the adventures of such creatures in E. A. Abbott's *Flatland* or A. K. Dewdney's *Planiverse*. Without attempting to be too scientific here, we can perceive the flat creature by "looking" at him in his surface, while he can perceive us only if we intersect his surface, such as by poking our finger through it. Suppose that such a 2-dimensional creature wishes to measure the shortest distance between two *X*'s that are fixed in his space. He extends a straight, 2-dimensional measuring rod in such a way that the rod passes through the centers of both *X*'s. The first *X* is located on the scale of the measuring rod at point X_a, and the second *X* at the point X_b. The shortest distance between the two *X*'s is, then, equal to $|X_a - X_b|$. Now, unknown and unknowable to the flat creature, his 2-dimensional space curves into the third dimension in such a way that the separation of the *X*'s in 3-dimensional space is much smaller than his shortest 2-dimensional separation, as shown in the figure. That is, *relative* to ourselves in 3-dimensional space, the shortest distance between the two *X*'s is, say, 50 cm, while *relative* to the flat creature, the shortest distance is, say, 100 cm. Perhaps in this way we can get some idea of how (i) each creature can exist within the world of the other in some limited fashion, and (ii) how the reality of their respective worlds can differ.

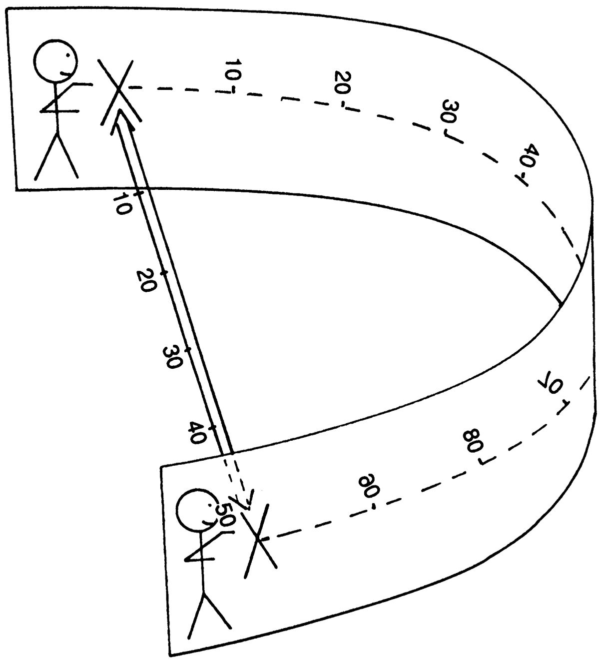

Figure 17.2 Two-dimensional figures measure the shortest distance between two *X*'s in their space, and find the distance to be 100 cm. However, a three-dimensional creature (not drawn) finds that the shortest distance between the same two *X*'s in his space is only 50 cm. Intended as a metaphor only, to show how one world can exist within another, and the laws of nature (of geometry here) can differ radically between worlds.

The above is all prolegomenon to the Darwinian question: What less intelligent life form served as the ancestor of *Homo sapiens*? Within our current theoretical framework the answer is not quite as simple as it is in classical Darwinism. In accordance with the AF, we can no longer envisage an anthropoid, deficient relative to homo sapiens in percipience and intelligence, occupying our same universe, while lacking the ability to interrogate it fully. Such an ancestor of modern man would have had to live in a universe whose structure and function was less complex than the one we know — less complex by some measure of the reduction in its intelligence (questioning power). This concept challenges our imagination: *The universe itself changes as the creature* "*evolves*." That is, the past that we calculate, by extrapolating our current universe backwards in time to an epoch preceding the appearance of *Homo sapiens* would not be the past that was actually experienced by our evolutionary forerunners. Not only the organism would have changed, but the entire universe relative to that organism.

Expressed in another way, it may not be a legitimate question to ask how the predecessor of homo sapiens "evolved" within our current universe, because the question itself implies the existence of a set of physical laws that were not in existence or operation until *Homo sapiens* had appeared. To approach the study of evolution within this new, relative framework, we must ask such outrageous questions as "What was the physics understood by an australopithecine ape?"

The unearthing of fossils of earlier life forms does not negate the new approach to evolution. These life forms exist within our own model of the universe in much the same way that the earthworm exists. However, the world experienced by these earlier life forms may have been quite different from the world that we model by extrapolating *our* current world backwards in time. There are, in a sense, multiple pasts: one consistent with the world view of *Homo sapiens*, others consistent with the world views of "earlier" creatures.

Can we, then, legitimately project our world backward in time in a continuous fashion, or will the worlds of our evolutionary ancestors be connected with our own only by a series of discrete jumps past discontinuities? Each organism is associated with its own unique world, operating in accordance with a consistent set of scientific rules, which constitute the answers to the questions that the organism is capable of asking. These worlds may not merge continuously as the organism evolves, giving rise to a jump sequence in evolution (saltation).

Crazy. Admittedly. But, as Niels Bohr once pondered, is it crazy enough? Can the classical, physical-biological evolutionary scheme produce the mind that developed quantum theory (upon whose principles much of physical evolution is explained)? Yes, if you believe that the mind discovered the theory but did not produce it. No, if you believe that the mind is part of the theory, which could, therefore, not have preexisted. The relativity of perception has been extended far beyond the insulated garden of simple sensory experience where it was earlier cultivated.

Evolution "beyond" man? If so, then such creatures can ask questions that we cannot ask. It would not be their ability to *answer* difficult questions that would set them apart from us, so much as the ability to *ask* such questions as we cannot conceive.

Extraterrestrials? Perhaps they exist. But if they share our universe, our science, they are of common intelligence with us.

A good deal has been said about the entropy theory providing informational constraints, but not specifying the mechanism of operation of our sensory receptors. This property of the theory permits us to make a prediction about extraterrestrial life forms. If they exist, and if "perception" carries the universal property of progressive reduction of entropy, then the psychophysical laws governing the operation of their sensory receptors will not differ substantially from our own.

THE ANTHROPIC PRINCIPLE

A new cosmological principle has gained prominence during the past decade. In 1974, Brandon Carter, then of Cambridge University, coined the term *Anthropic Principle* (Greek, *anthropos*: man). This principle has served as a balance against the Copernican Principle, which states that no part of the universe is more privileged than any other. Copernicus, of course, displaced the idea that the earth is the center of the universe, by the heliocentric theory, which relegated earth the status of "just an ordinary place." The Anthropic Principle shifted the emphasis back slightly toward the observer on earth. In Carter's words, "What we can expect to observe must be restricted by the conditions necessary for our presence as observers." The Anthropic Principle is classified as Strong and Weak.

The Weak Anthropic Principle (WAP) was suggested by R.H. Dicke in 1961. It may be stated (Breuer, 1991),

"Because there are observers in the universe, the universe must possess properties which permit the existence of these observers."

That is, the observer's position is, in a sense, privileged, thus inveighing somewhat against Copernicus.

The Strong Anthropic Principle (SAP) was hypothesized by Carter in 1973. As stated by Breuer,

"The structure of the universe and the particulars of its construction are essentially fixed by the condition that at some point it inevitably produces an observer."

The SAP has been stated in somewhat stronger terms by Tony Rothman (1987) in a delightful article in Discover magazine (articulate, dramatic and humorous):

"Most scientists interpret the SAP to mean that the universe must be nearly as we know it or life wouldn't exist; conversely, if life didn't exist, neither would the universe."

Notice how close this formulation of the SAP is to the principles of relativity of perception and relativity of existence. The pull-out from Rothman's article (although not appearing verbatim within the text of the article) states:

"... Its (the Anthropic Principle's) extreme form says the laws exist *because* we behold them, making man the creator, not just the measure, of all things."

The first two formulations, by Breuer, stand firmly on the side of an objective universe, even if that universe will "inevitably" produce an observer. However, the two formulations cited from Rothman's article lean decidedly towards a subjective universe, an idea that upsets some otherwise dispassionate scientists. Accordingly, I entertain some fears that the contents of the previous section on the evolution of evolution may cause apoplexy in the vascularly vulnerable.

The Anthropic Principle is a fascinating subject. The interested reader is referred also to the 700-page tome by Barrow and Tippler. Many celebrated physicists, such as J.A. Wheeler, have supported the principle. Wheeler's Participatory Anthropic Principle is expressed by Barrow and Tippler as

"Observers are necessary to bring the Universe into being."

I have introduced the Anthropic Principle at this point because it seems, at least superficially, to be allied to the principle of relativity of perception. Most books dealing with the Anthropic Principle give casual references to Berkeley's philosophy. I shall not even attempt to expound further on the subject here. The reader is referred to the excellent monographs cited.

QUANTUM THEORY AND PERCEPTION

Quantum theory was introduced early in this book (Chapter 2) to show that it was readily amenable to analysis by information theory. Prior to the act of observation, a physical system exists in a combination of states represented by a wavefunction (cf. many possible outcomes to an event engendering uncertainty). Observation (I prefer perception) of the outcome collapses the wavefunction (cf. perceiving the outcome of an event leads to loss of uncertainty or gain in information).

We can now regard the process of establishing the wavefunction as the active or interrogative phase of perception, and the process of collapsing the wavefunction as the passive or assertive phase of perception.

Quantum mechanics seems a more natural medium in which to apply the entropy theory than classical mechanics, in which energy, momentum, etc. are distributed continuously. In quantum mechanics, the passive phase of perception is accomplished abruptly. In classical mechanics, the passive phase of perception occurs slowly, and seemingly continuously, distributing itself through an extended process, which we regard in the spinning of a top or the motion of a pendulum.

We as "mesoscopic" creatures (Greek, *mesos*: middle), that is, half-way between microscopic or atomic scale and truly macroscopic or stellar scale, happen to dwell in the realm of classical mechanics. We are flanked by atomic events on one side and astronomical events on the other. Is it the case that continuity of perception, or the apparent continuity, is a feature only of this middle-land?

From the viewpoint of the entropic theory of perception, the smallness of the scale of quantum events is not the cardinal feature distinguishing these events from mesoscopic events; rather it is the inability of us mesoscopic creatures to perceive the occurrence of quantum events continuously. For example, we perceive the effect of the electron striking a screen, but we cannot perceive the electron continuously in its trajectory toward the screen because such continuous perception would require scattering a stream of photons from the tiny electron, which cannot be done. Hence we have before-the-event uncertainty and after-the-event perception, giving rise to a discrete form of the *H*-function. However, macroscopic events such as astrophysical events, can also not be perceived continuously by mesoscopic creatures, for a number of possible reasons. "Terrestrial" reasons include the large time scale of astrophysical events, visibility only in short or long wave length electromagnetic radiation that can be captured on film but not witnessed directly by eye, rotation of the earth on its axis, etc. More fundamental reasons for intermittent perceivability include eclipse of a planet as it revolves about its sun, and self-eclipse of a binary star. The mesoscopic luxury of continuous perception with sensory adaptation is forfeit, and therefore, it is not outrageous to expect in this macroscopic realm, effects of a quantum nature.

The idea of macroscopic quantization is discussed in a paper by Daniel Greenberger in 1983.

SUMMARY

The above are purely speculations, and extrapolations beyond the core of the entropic thesis. I would like to leave you with the following thoughts.

It is possible to construct a mathematical theory of perception which is consistent with the idealist philosophy of George Berkeley. This theory may not be the unique "incarnation" of Berkeley's ideas, and it certainly does not incorporate his theology, but it does seem to capture the spirit of his idea of the relativity of perception. The fundamental mathematical formalism of the entropic theory of perception is contained by the simple equation, $F = kH$. This equation is noteworthy for a number of reasons. First, and most obviously, it is mathematically and conceptually similar to Boltzmann's equation, $S = -k_b H$, suggesting (but not yet proving) a link between the physical entropy, S, of a system, and the perceivability of the system. The equation is also noteworthy for its utilitarian value in understanding and unifying sensory processes. When the informational entropy, H, is evaluated as an explicit function of stimulus intensity, I and time, t, the equation $F = kH$ allows us the derive mathematically nearly all of the laws of sensory science involving the variables F, I and t, which have been discovered empirically, or by measurement, over the past one and a third centuries. It also permits us to predict the results of many experiments in psychophysics and sensory physiology that have not yet been performed. We are empowered to obtain, by mathematical analysis of our experiments, knowledge that was previously unavailable to us. The explicit form of the *H*-function permits us to incorporate the information concept into sensory science in a manner not previously possible. For example, channel capacities can be calculated in a very simple manner from neurophysiological adaptation data. The *H*-function gives rise to the various sensory laws not by specifying their physical mechanism but by utilizing the quantity of information transferred as a constraint, in the manner of a law of conservation.

We have not, in these pages, exhausted the analysis of sensory experiments that can be performed involving the single, steady stimulus and variables I, F, t. It is to be hoped that the reader can now carry out the theoretical analysis of many of these experiments using the methods presented. Moreover, many investigations which may have been executed purely to search and find may now be hypothesis-driven. That is, it should be possible to predict results before measurements are actually made. The reader is reminded, however, that in a global theory as this one purports to be, we strive for one or two equations that describe all natural phenomena to a high degree of approximation, to replace scores of unrelated equations each of which may describe a single phenomenon with great precision. The importance of controlling and reporting the time variables has been emphasized. For fine theoretical analysis, one should know the duration of the stimulus, the time since stimulus onset, and the extent of prior adaptation. We have also been led to the point where correlation between neural and behavioral events can be made mathematically, albeit in preliminary fashion.

$F = kH$ was suggested as a mathematical representation of Berkeley's ideas, but when the equation was analyzed carefully from a physical point of view, it was found to require for its implementation two processes: an active process whereby uncertainty or doubt was instilled into the perceiving system, and a passive process whereby uncertainty was removed. The active process was a kind of interrogative or questioning process, and the passive process a kind of assertive process. If the perceptual process was to be self-contained, not requiring the intervention of an external agency, then both active and passive processes must be accommodated by the perceiving system. Therefore, perceptual autonomy required the existence of a perceptual unit, which mediated both active and passive components. This perceptual unit is, by definition, the simplest self-contained structure capable of the act of perception. The passive component of the perceptual unit contains the sensory receptor, and it was suggested that the active component consists of a mechanism for self-stimulation of the sensory receptor. The concept of the perceptual unit was built progressively throughout the latter part of the book, but the building process was not completed.

Since the equations of the entropic theory are the physical embodiment of the Berkeleian philosophy from which they took origin, the theory carries in its genetic base, so to speak, the relativity of the perceived world to the perceiver. *To a certain extent*, the perceiver determines the nature of the world he perceives. In the final chapter, we let loose the fetters that were restraining us to the limited sphere of sensation of steady signals of the intensity type, and speculated about perception of the world at a higher cognitive level: perception of planets and worms, perception of the laws of physics. As we extended the principle of relativity of perception from the single sensory receptor to the whole organism and, ultimately, to the whole species, it was necessary to generalize the active-passive, or interrogative-assertive function of the receptor to an interrogative-assertive function of the species as a whole. One possibility for such a function is the AF given above. Perceptual relativity at the level of the species demands a reexamination of the Darwinian principle of evolution.

At the higher cognitive level, perceptual relativity leads us to a position that is nearly indistinguishable from that of the Strong Anthropic Principle. That is, considerations that have issued from biology have led to about the same position as speculations that have issued from cosmology, ending the book with a strong statement for the unification of science.

NOTES

1. *Objectivity* is a better word than *validity* here.

2. I cannot be consciously aware that a given stimulus is self-generated, because the self-generated stimulus is only a component of a complex that, in its totality, is necessary to produce awareness of a stimulus.

3. A digital or computer model would demonstrate nothing of importance. We are now looking for a physicochemical mechanism (one of the few places in this book where mechanism comes into play) that will *act out* or *live* the role of the perceptual unit. We are trying to create a functional unit that can exhibit some rudimentary aspects of awareness.

4. *Nearly* universally, because some people tend to ask for an indefinite number of clarifications of the question, and others just question my sanity for asking.

5. If we regard the universe as closed or finite, in the manner suggested by Einstein's general theory of relativity, the "point" in space at which all matter was collected should more properly be taken as all the space in the universe. Similarly, the expansion that succeeded the big bang should more properly be conceived as an expansion of all space, not just an expansion of matter within space.

6. Radiation is a form of energy, but we recall from Einstein's $E = mc^2$ relation that energy and matter can interconvert, one to the other.

7. The longevity of the universe depends on the *critical cosmic density*, for which the reader is referred to the literature.

8. There are remains of simple organisms such as bacteria and blue-green algae in rocks 3400 million years old (Clarkson, 1986).

9. "One might say "the eternal mystery of the world is its comprehensibility." ... The fact that it [the world of our sense experience] is comprehensible is a miracle." Albert Einstein (1954).

10. We are giving the redoubtable professor no less than he gave us. To deal with the extraordinary coincidence that gravitational and inertial mass are found to be exactly equal, Einstein created the general theory of relativity, in which the two masses are, effectively, constrained to be equal. To deal with the extraordinary coincidence that the universe, as perceived by man, just happens to be intelligible to man, we are creating the principle that intelligibility is a necessary condition for existence of the universe.

REFERENCES

Abbott, E.A. 1972. *Flatland: A romance of many dimensions*. Barnes and Noble, New York.

Barrow, J.D. and Tipler, F.J. 1986. *The Anthropic Cosmological Principle*. Oxford University Press, New York.

Breuer, R. 1991. *The Anthropic Principle: Man as the focal point of nature*. Translated from the German by H. Newman and M. Lowery. Birkhäuser, Boston.

Clarkson, E.N.K. 1986. *Invertebrate Palaeontology and Evolution*. Second Ed. Allen and Unwin, Boston.

Dewdney, A.K. 1984. *The Planiverse: Computer contact with a two-dimensional world*. Poseidon Press, New York.

Einstein, A. 1954. Physics and Reality. In: *Ideas and Opinions*. Crown Publishing Co. New York.

Greenberger, D.M. 1983. Quantization in the Large. *Foundations of Physics*, **13**, 903-951.

Gulick, W.L., Gescheider, G.A. and Frisina, R.D. 1989. *Hearing: Physiological Acoustics, Neural Coding, and Psychoacoustics*. Oxford University Press, New York.

Narlikar, J. 1977. *The Structure of the Universe*. Oxford University Press, Oxford.

Norwich, K.H. 1983. To Perceive is to Doubt. The relativity of perception. *Journal of Theoretical Biology*, **102**, 175-190.

Rothman, T. 1987. *A 'What you see is what you beget' Theory*. Discover, May edition.

Weinberg, S. 1977. *The First Three Minutes*. Bantam Books, New York.