TOWARD THE BEGINNING OF TIME

Gregory L. Baker

I. Introduction

1) *The Problem*

To contemplate the notion of time is often to review the events which have occurred in a given time interval. These events may be those of a single day; perhaps a day occurring in the immediate past where the events are still remembered clearly. Perhaps a longer time span may be considered—even back toward the frontiers of one's recallable memory in early childhood. There are also the events and time span associated with the collective memory of a people; namely their history. And through the deductions and empirical data of various sciences one can look even further back in time to prehistory and even to paleological times when the earth was young. Still more remote are those times which astronomy associates with the formation of stars, galaxies, and perhaps the universe itself. It is toward this latter time, the beginning of the universe, that this essay will look. Such a time will, in fact, mark the beginning of time.

Time, and also space, are properties of the material, natural world, (The Special and General theories of relativity, cornerstones of 20th Century physics, demonstrate that space and time are irrevocably conjoined.) Not only are space and time seemingly objective properties of the natural world; they are the means whereby we view and measure that world. Therefore, it is exceedingly difficult to discuss spacetime in terms which are other than its own, that is, to escape from a kind of unsatisfactory circular description. Perhaps the best which can be hoped for is a heightened awareness of this limitation.

We then ask if there ever was a time when spacetime did not exist or at least was, in principle, unmeasureable. Another way to put the question is, "Can we go back in time to the beginning of time, or the moment of creation?" Of the general answers to this question, the simplest would seem to be the negative answer. In this case the beginning of the world is pushed back infinitely far in the past and one can say that the world was never created but just always "was." This type of thinking achieves a certain degree of scientific respectability in the theory of the Steady State Universe put forward in the late 1940's by Bondi, Gold and Hoyle.[1] However since the 1960's the experimental evidence, especially the background microwave radiation, the evolution of quasars, and some radio source effects, has rendered the theory unworkable. Even the fact that the night sky is dark militates against the steady state theory.

The other logically possible answer assumes that there really was a beginning of time. If true, this assumption provides semantic, philosophic, and even theological problems. For example, consider the following question: "If the creation of the universe was the beginning of time, what was God doing *before* the universe was created?" Once again the difficulty here is that the very question of the beginning of time is couched in terms of time, that is, in terms of itself. One seems to need another time dimension which will encompass the origin of the first time dimension. Clearly this is impossible, especially since it begs the question of a third time dimension to deal with the beginning of the second one, and so on, *ad infinitum.*

In the same vein, Swedenborg relates the following experience:

> I was once myself in such a state, thinking about what God was from eternity, what He did before the world was created, whether He deliberated about creation, and thought out the order to be pursued; whether deliberative thought would be possible in a vacuum; with other vain things...it was given me to comprehend that the eternity of God is not an eternity of time; and as *there was no time before the world was created,* it is utterly vain to think about God in such a way...I concluded that God did not create the world in time, but that *times were introduced by God with creation.* [TCR 31, emphasis added]

Therefore, despite a certain relativity in its measurement, there is only one time dimension for the created universe. The main task of this essay will be to work as closely as possible, in view of contemporary science, philosophy, and theology, to the origin of that time, recognizing the limitations imposed by the subject itself.

2) *Theological Origins of Time*

The origin of time is almost by definition attributable to the Creator of the universe. Swedenborg describes several facets of the relationship of God to time, such as the following:

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[1]In this theory, matter fills all space and the universe obeys the so-called "perfect cosmological principle" which states that the universe is not only isotropic in space (looks the same in every direction) but is unchanging in time as well.

> *...In relation to time [God's infinity] is called* [illegible]*ty,* becau[illegible] 'to eternity' is an expression applied to what is progressive, which is measured by time without limit.
>
> ...in God...there is nothing of space and time; nevertheless, the beginnings of these are from God; and from this it follows that by immensity His infinity in relation to space is meant, and by eternity His infinity in relation to time. [TCR 31]
>
> ...From all this it is now clear that God, Who is uncreate, is also eternal. [AE 1130]

God is eternal, acting in all of time, originating time, but not limited by time, since time is on a lower plane than eternity. One is tempted to say that time is a subset of eternity. But even this is not adequate since the elements of the set corresponding to time are not really elements of eternity. There is a difference of kind. Swedenborg speaks of the difficulty finite-minded mortals have in conceiving of eternity:

> He who has no knowledge of God apart from time and is unable from any perception to think of Him, is therefore utterly unable to conceive of eternity in any other way than as an eternity of time; in which case, in thinking of God from eternity he must necessarily become bewildered; for he thinks with regard to a beginning, and beginning has exclusive reference to time.... [DLW 76]

In another place, a distinction is made between thinking from "natural light"; that is from a framework of spacetime and sense experience, and thinking from "spiritual light" which logically must be a framework outside spacetime, a kind of higher thought in which spacetime surroundings are unfelt and eventually transcended. Certainly this latter type of thought occurs frequently in the realm of affections but seems more difficult to achieve as an intellectual objective.

> These things, I know transcend the ideas of thoughts that are in natural light, but they do not transcend the ideas of thoughts that are in spiritual light, for in these there is nothing of space and time. Neither do they wholly transcend ideas that are in natural light; for when it is said that infinity of space is not possible, this is affirmed by every one from reason. It is the same with eternity for this is infinity of time. If you say to eternity', it is comprehensible from time; *but 'from eternity' is not*

> *comprehensible, unless time is removed.* [DLW 156, emphasis added. See also HH 167]

From the above statement it is obvious that the attempt to convey a clear notion of "eternity" as applied to God is doomed to failure because the mode of description is natural whereas the object is spiritual. Despite this difficulty, the last line of the quotation points rather vividly to the idea of a beginning, at least in man's concept of time. Man cannot think *from* an infinity of time, but only *to* an infinity of time. Therefore, a beginning is almost a psychological requisite.

> The angels declare that while they can conceive God from eternity, they can in no way conceive of nature from eternity....[DLW 76]

> ...[man] is unable to form any conception of God's immensity antecedent to space, or His eternity antecedent to time.... [TCR 31]

The psychological problem of a beginning exists even with the "steady state" theory of cosmology. In this theory the universe is considered to have appeared the same at all times—yet one still wonders "when" this universe first appeared in its full-blown state. Even in this case the human mind searches for a beginning, and the Writings support the search as well as the reality of the beginning. Repeating a previous quotation:

> ...it was given to me [Swedenborg] to comprehend that the eternity of God is not an eternity of time; and as there was no time before the world was created, it is utterly vain to think about God in such a way....I concluded that God did not create the world in time, but that *times were introduced by God with creation.* [TCR 31, emphasis added]

In summary, we note a distinction between "eternity," as applied to God, and "infinity" as applied to the material world. While "eternity" can be extended infinitely backward and forward, "out-of-time"; an infinity of time seems to apply only to an infinite future, not an infinite past. The world was created, and that event marked the beginning of time (and also space.)

There is another indication from the Writings which bears indirectly upon the question of beginning of time. There is a correspondence between man and the universe; that is, man is a microcosm of the universe. "...all things of the universe, viewed as to uses, represent man as an image..." (DLW 319).

Now the inmost of man is his soul, whi unique to each individual. As the following quotation shows, the soul is the first of man's essentials and, for purposes of a time beginning, the soul also is shown to begin in time.

> ...man gets his beginning from the soul, which is the very essence of the semen; and the soul not only initiates, but also produces in their order all things that pertain to the body, and afterward all things that proceed from the soul and body together, which are called operations. [TCR 166]

If, therefore, man is a microcosm of the universe, then his beginning must be analogous to the beginning of the universe. Man is also a microcosm of the universe in that his soul, which had a beginning in past fime, will live forever into future time. Similarly the universe which seems to have begun at a finite interval of time in the past will, depending on its density, have an infinite existence into the future.

One final note which is related to the development of man's soul, body, and operation proceeding, as well as to the question of the beginning of time, deals with the nature of God Himself. The notion of a Trinity is really the product of the existence of a world and specifically the existence of man.

> Before the world was created this Trinity was not; but after creation, when God became incarnate, it was provided and brought about, and then in the Lord God the Redeemer and Savior Jesus Christ. [TCR 170]

God, the Father, is the Divine Love and Wisdom which exists from eternity (out of time). The Son or Jesus Christ is, in the most general sense, the face of God which we see, albeit indistinctly. This aspect of God together with the Holy Spirit is concomitant with the existence of man. While these manifestations of God produced no change in God Himself, but rather in the human perception and reception of God, nevertheless these changes did occur in time. Therefore one finds again a development or kind of evolution which mirrors, to some extent, the development of the universe.

3) *Psychology of Time*

A quick glance at, for example, J. T. Frazer's[2] collection of essays on time shows marked intrusion of time in the human psyche. Psychological time is the human perception of time and involves

[2] J. T. Frazer, ed., *The Voices of Time* (New York: George Brazmiller, 1966).

several major areas, including the question of time's passage, memory and anticipation, apparent causality, and time directionality. (A distinction should be made between psychological time, described by Einstein as I-time or subjective time,[3] and the metaphysical time introduced previously. By metaphysical time is meant time as it really is, by definition described inadequately, but nevertheless representing the effort to see the reality of time, the properties, and the "beingness" of time.)

Is time perceived as having a preferred direction? The "passage of time" is a common phrase indicating perhaps motion of a clock's hands, growth of new life, decay and death of old life, changing seasons—even states of increased depth in friendship, understanding, wisdom, and so forth. One has this sense that time is like a river—the properties of time do not change, but something seems always to be going past.

We have a memory of the past, which when organized or collated with other memories, becomes formalized as a history. In this sense we know the past; we have been there. Based partially on this past we anticipate and project to the future, although our statements and predictions of the future do not carry the same degree of certainty as our statements about the past. Anticipation and memory are not equal knowledges. Of course, this statement of inequality presupposes a certain lack of determinism, a certain freedom in affairs. (From a psychological view the actual existence of freedom may not be important in this context, since only the perception of freedom is meaningful for the perception of time asymmetry. However, the Writings support, in an absolute sense, human freedom within the stream of Divine Providence.) The discrepancy in certitude between anticipation and memory leads to a directionality in time, an unrolling of time as an endless blank sheet upon which history is to be written.

A directionality or asymmetry of time therefore appears in the context of memory and anticipation. It also arises in the perception of causal relations. Cause always precedes, in time, its resultant effect. Event A, which appears to cause event B, always precedes event B, assuming event B is derived from or could only happen because of an earlier event A. A later event cannot cause an earlier event. While the science fiction of a time machine situation provides entertainment, there is always some contradiction or logical difficulty in such stories. If a person goes back in time to affect

[3] Albert Einstein, *The Meaning of Relativity* (Princeton: Princeton Univ. Press, 1953) p. 1.

historical outcomes and events, would it not ,easonablı ..at he could affect his own outcome in the present? If his own outcome were affected, then he might not be the same person going back in history, and so forth. A kind of spiral of illogic develops which exposes the concept of time machines as absurd. Therefore the notion of causality also reinforces the concept of the "arrow" of time. (Since the advent of the Relativity Theory, one should really consider both spatial and temporal separation when determining possible causations.)

It has been stressed that the asymmetry of time is a perception of the physical reality. Yet, the physical reality (assumed to be partially measureable by scientific means) should have a connection with the perception, especially since the brain functions according to chemical and physical laws which are strongly applicable in space and time. Therefore we turn now to the question of a time arrow in the physical world, the world which is subject to the scientific method of enquiry.

II. Is There an Arrow of Time?

1) *Time Reversal Invariance*

Perhaps the most well-known equation of physics is that which relates the acceleration of a particle to the applied force: Isaac Newton's second law of dynamics. The concept of time reversal invariance may be easily demonstrated with this equation. For the sake of simplicity we assume a force **F**(**r**) which does not depend explicitly on time or velocity—a typical example would be the electrostatic Coulomb force. Let this force act in a classical determinatic fashion upon a particle of mass, m. Then Newton's second law provides that the particle's acceleration is proportional to the applied force, or

$$m \frac{d^2\mathbf{r}}{dt^2} = \mathbf{F}(\mathbf{r})$$

and the trajectory **r**(t) will be a solution of the differential equation. We next ask the effect of interchanging the time variable t with a new time variable, -t. Then the equation becomes

$$m \frac{d^2\mathbf{r}(-t)}{d(-t)^2} = \mathbf{F}(\mathbf{r}(-t)).$$

But the differential operator

$$\frac{d^2}{d(-t)^2} = \frac{d^2}{dt^2}$$

and therefore one obtains

$$m \frac{d^2\mathbf{r}(-t)}{dt^2} = \mathbf{F}(\mathbf{r}(-t))$$

which is precisely the form of Newton's equation before the change of time variable. We say, therefore, that Newton's second law is invariant under time reversal. As a result, the time reversed solution is also a solution to the problem. For example, consider an object in a constant gravitational field. If the object falls, it necessarily picks up speed as it falls. Now take a motion picture of the falling particle and run the film backward. The film shows a particle traveling upward with a decreasing speed. Yet this time reversed motion is just as valid in nature, or physically, as the original motion. Therefore the time reversed motion is equally as physical or meaningful as the original motion. The factor which determines which motion actually takes place is the set of initial conditions laid upon the situation. If the particle were allowed to fall or be thrown in the free-fall direction, then the motion indicated by the film running forward would result. On the other hand, if the particle is thrown "up" the resultant motion would, for a time, correspond to that shown when the film is run backward. It is important to realize that the initial conditions are not part of the law of motion itself, but instead act to select one of the many solutions (trajectories) provided by the equation of motion.

The remarkable feature of the above example is its non-uniqueness and almost complete generality. The equation of motion, whether classical, relativistic, or quantum-mechanical—whether the force is gravitational, electromagnetic, weak or strong nuclear, is almost with exception invariant under time reversal.[4]

The point of the above little exercise, then, is to show that trajectory or motion shows no preferred direction in time—*until boundary conditions are imposed.* That is, if we set up the experiment in the right way, the time reversed trajectory can be achieved.

2) *Entropy Increase and Time Asymmetry*

It is very important to note that the previously described

[4]P. C. W. Davies, *The Physics of Time Asymmetry* (Surrey Univ. Press, 1974), pp. 22-27.

symmetry in time refers to systems w the individual components may be studied in detail; that is, microscopic or small scale systems. In fact, time reversal invariance may only apply to small scale systems. On the large scale there does seem to be time asymmetry. The second law of thermodynamics states that all isolated macroscopic systems tend toward a state of maximum disorder (or maximum entropy). This effect is demonstrated in everyday life by countless examples: automobile engines break down, hot objects cool, eggs do not unscramble, and so forth. Every complex physical system evolves by an increase in entropy. Even biochemical systems such as living cells can be shown to produce entropy—if not in themselves, then at least for the universe as a whole. For example,

> When living organisms grow they obviously decrease in entropy, because of the highly structural nature of living matter. But this decrease in entropy can occur only if the surroundings increase in entropy. Put in another way, living organisms create their own internal order at the expense of the order of their environment, which they cause to become more random.[5]

Even macro-systems, which are explicitly composed of micro-systems such as molecules, develop temporally in an asymmetric manner. Consider the example of an impermeable box of molecules for which, as an initial condition, the molecules are all located in one half of the box. As time passes, our intuition suggests that the molecules will spread uniformly throughout the box as in fact they do. In reference to time symmetry, we now ask for the likelihood of a collection of uniformly distributed molecules bringing themselves *together* in one half of the box. Clearly such an event would be very rare. Therefore the system as a whole seems to possess a temporal asymmetry.

The fact that entropy increases gives a reality to the arrow of time. In this sense, past and future can be determined, at least in principle, by the measurement of increasing entropy or randomness. Even further, one can fit loosely the pattern of cause and effect into the framework of increasing entropy. Cause and effect sequences will result perhaps in decreasing entropy locally while at the same time increasing the entropy of the surroundings. In this sense, the cause and effect sequence would be analogous to

[5]A. L. Lehninger, *Bioenergetics* (Menlo Park, CA.: W. A. Benjamin, Inc., 1971), p. 28.

the biological growth sequence. It becomes evident that:

> Although we are forced to conclude that the laws of physics do not themselves provide a time asymmetry, it is one of the most fundamental aspects of our experience that, as a *matter of fact*, the world is asymmetric in time. This is sometimes expressed by saying that the temporal asymmetry is 'fact like' rather than 'law like', or 'extrinsic' rather than 'intrinsic'.[6]

3) *Time Asymmetry via Boundary Conditions*

"Asymmetric behavior is observed as a result of the natural selection of certain types of special *boundary conditions* in preference to others."[7]

Like initial conditions, boundary conditions are a set of circumstances imposed on a dynamical system. By specifying boundary conditions, one chooses a particular motion or behavior from among a whole family of behaviors. A typical example of a dynamical problem with certain boundary conditions (called a boundary value problem) is the motion of a vibrating string. Perhaps the boundary conditions are such that the two ends of the string remain fixed during the motion. These particular conditions then specify the motion of the string to be of a certain type, which is only one member of a large family of possible motions. In this example the steady state motion is that of certain standing waves whose allowable wavelengths depend on the string's length. If, on the other hand, these boundary conditions were not specified, then the allowed wave motions would exhibit discretely more variation.

What, then, are the boundary conditions which lead to the time asymmetry observed on the global scale in spite of small scale time invariance? The current answer to this question lies in the creation of the universe itself. The initial (boundary) conditions at the epoch of creation picked, out of all possible dynamical solutions, are those motions which have a directionality property. The directional property leads to the law of increasing entropy which is the manifestation of time's arrow in the physical world. Quoting Davies again, we read:

> Whether or not we can also meaningfully identify the *origin* of the asymmetry is a subtle point. However it emerges...that the event referred to as the *beginning* of the universe (in the big-

[6]Davies, p. 27.

[7]Ibid.

> bang sense) may be described as the terr . extremit·· at which there is a *mismatch* between the boundary conditions of the global dynamical motion as determined by gravity, and the microscopic particle motions of the cosmological material, as determined by electromagnetic, weak and strong interaction. In other words, there is no correlation between the large and small scale motions of the universe. In that case, it turns out that entropy will increase for the overwhelming majority of initial conditions of the cosmological material. Therefore this mismatch might be regarded as the ultimate origin of time asymmetry in the world, and for the ever expanding big-bang models, mismatch simply accepted as a fact of nature, like the mass of the proton.[8]

The mismatch referred to in the quotation is the global effect of gravity attempting to collapse all matter and radiation, pitted against the microscopic high energy state caused by the other forces from which is derived the initial expansion. The effect of gravity would run completely counter to the expansive effect of the other forces.

The fact that a physically measurable arrow of time exists is therefore seen as further evidence for a beginning of time. Indeed if there were no beginning then it seems doubtful that we would observe any difference between past and future, since there would be no boundary condition. The creation event caused the large-scale asymmetry of time, and therefore time asymmetry is evidence for a beginning of time.

Let us examine the mediate cause of entropy increase, which is equivalent to time asymmetry. Of the four (or more, or less) fundamental forces in nature perhaps the most profound and far reaching is gravity. Weak as it is there is no other force which penetrates throughout all space and acts on all particles. (Swedenborg also gave gravity a position of pre-eminence in the set of three natural atmospheres or auras; purer ether is given as universal and as the origin of all gravitation, L. J. Post. 312) Gravity cannot be shielded as the electric force can, nor does it have the limited range of nuclear forces. Any static system of massive particles will ultimately collapse because of gravity. The most complete gravitational collapse is that of the black hole, where collapse occurs to such a degree that even information (in the form of light signals) is prevented from leaving the "hole" by the overpowering gravitational field. Because of this tendency to

[8]Davies, p. 7.

collapse

> ...a self-gravitating system has no true equilibrium configuration. It therefore possesses an infinite reservoir of negative entropy....We have reached a remarkable conclusion. The origin of *all* thermodynamic irreversibility in the real universe depends ultimately on gravitation. Any gravitating universe that can exist...*must* be asymmetric in time, both globally in its motion, and locally in its thermodynamics...through the production of thermal gradients.[9]

In this section we have seen that time has a direction, despite its reversibility on the micro-dynamic scale. This direction corresponds to the evolution of natural phenomenon toward states of higher entropy, and this directionality is ultimately made possible by the existence of a creation event—a beginning of time.

III. Cosmological Models

1) *Big Bang vs. Steady State*

Given the existence of time asymmetry and the resultant implication of a beginning of time, it is reasonable to inquire into the physical nature of this beginning by examining present models of the universe. Such models are termed cosmological. They attempt to explain the overall regular features of the universe without reference to particular galaxies, stars, and so forth. Cosmology, therefore, does not deal with stars, it deals with a cosmological "fluid" of matter and radiation fields.

Until fairly recent times, some version of the "Steady State" model of the universe was in vogue. It's basic assumption is the so-called "strong" or perfect cosmological principle, which states that the universe, by and large, presents the same aspect to all observers from every space location *at any time.*[10] In other words, the universe always has been and always will be as it is now. This model was proposed by Bondi, Gold and Hoyle in the late 1940's as a means of overcoming some discrepancies between the age of the earth as determined by geologists and the apparently shorter age of the universe as calculated (erroneously) by astronomers. There was also

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[9]Davies, pp. 108-109.

[10]Jagjit Singh, *Great Ideas and Theories of Modern Cosmology* (New York: Dover, 1970), p. 192.

the philosophic uneasiness of the scientist faced with the unknowability of a cration event or beginning of time.

Because of the well-documented expansion of the universe, the steady-state model had to be modified. It became necessary to adopt the hypothesis of a continued creation of matter (hydrogen atoms) in order to maintain the steady-state aspect of this model; that is, to fill the vacancies left by the continuing expansion. This solution of continual creation presented difficulties with respect to other physical laws. How could matter be created from nothing (even though only about one new atom per litre per 100,000 years was the required creation rate) in violation of the principle of baryon number conservation—a principle well established in high energy interactions?

To overcome the mass-energy conservation problem, Hoyle and Narlikar invented a mathematical artifice called a C-field which was an energy field whose energy became more negative as energy was used from the field to create particles. Unfortunately there is no evidence to support the existence of such a field.

The present standard cosmological model is that of the "Big-Bang." In this model the universe is imagined to have had an explosive birth some 10 to 15 billion years ago as a kind of primordial fireball which flung matter and radiation outward, simultaneously creating time and space. This expansion of the universe is still evident in the motion of galaxies and other sources.

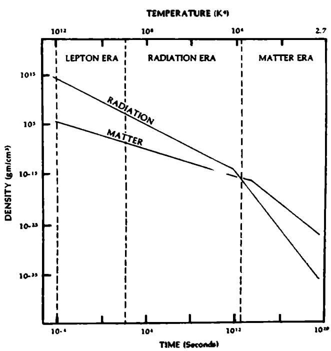

Figure 1 History of the universe from 10^{-5} seconds after the big-bang until the present

In the expansion process the universe has cooled from what may have been an infinitely high temperature at creation to a cool 3°K above absolute zero at present. The diagram above gives some idea of the temperature, density, and time scales involved. One notes that these scales are logarithmic and that the interesting changes occur as these parameters change by powers of ten.

It is also worth noting that the time scale only goes back to the 10^{-5} seconds. Prior to that moment, the physics becomes very complicated and somewhat speculative, although undoubtedly most interesting. These first moments will be discussed in more detail in Sections IV and V of this paper.

Since this discussion of the beginnings of time assumes the reality of the Big-Bang it will be useful to survey the experimental basis of the theory.

2) *Experimental Evidence*

One of the most important astronomical datum is the shift in atomic spectra frequencies as observed in stars and distant galaxies compared to the spectral frequencies for the same elements as measured on earth. The effect is a manifestation of the so-called Doppler shift,[11] named after the Austrian physicist, Christian Doppler, who observed the effect in 1842 while taking optical spectra of the stars. Since that time huge quantities of sources have been catalogued as to their Doppler shift, the vast majority of them showing a shift toward a lower frequency (a red shift). According to the Doppler effect interpretation, these sources are receding from the earth. (A few, like the Andromeda galaxy, show a blue shift, indicating approach.) In 1929 Edwin Hubble published extensive data to show that the velocity of recession was dependent upon the distance from the given source to the observer. The dependence seems to be approximately linear. At any rate, assuming that all galaxies behave this way, we may conclude that the universe is expanding in some sense.

In 1965 Penzias and Wilson of Bell Telephone Laboratories found

[11]The Doppler shift is an easily recognized effect, at least for sound waves. If a source of waves, whether sound or light, is in motion relative to the observer, the waves will appear to have a modified or shifted pitch (frequency). For example, when standing beside a road one may observe that a car whose horn is sounding will seem to have a different horn pitch as the car approaches from the pitch observed as the car recedes. The same effect also applies to light waves, which the stars are constantly radiating toward us.

an unexplained amount of background noise in a microwave antenna system they had devised. It turned out that the noise spectrum corresponded to "blackbody" radiation whose characteristic temperature was 2.7°K. These results have since been verified, and in hindsight one sees that they were predicted as early as 1941 by the molecular spectra of CN (cyanide) in interstellar cyanogen. This low temperature radiation field is found to be isotropic to within a fraction of a percent and therefore fits precisely the need of the big-bang model for a radiation field which has cooled by expansion from the primeval explosion. This radiation field is not explicable in terms of steady state cosmology.

Radio source counts, whether from stars or galaxies, made with radio telescopes and satellite-mounted telescopes indicate a distribution of sources and intensities which show evolutionary effects. It appears that the older sources, those which are further away (which must be older because of the time required for the light to reach us), are in fact brighter, indicating a definite bias against the steady state view and favoring a more compact earlier state of the universe. Similarly, studies of quasi-stellar objects (probably galaxies), which appear to be very old sources, are really anomalously bright when compared to the contemporary universe in our vicinity. Both radio source counts and quasars are areas of active study and controversy. Nevertheless, the evolutionary big-bang model seems to provide a natural vehicle for these effects.

The element helium occupies a rather unique place in the study of the abundances of elements. While most of the elemental abundances can be explained in terms of stellar evolution by nuclear processes which manufacture elements within individual stars, there is too much helium to be accounted for in this way. Therefore one suspects that helium had a cosmological origin. The important point is that nucleo-synthetic processes require a great deal of energy or very high temperatures. If the helium relative abundance is such that the stellar furnaces are not sufficient to the task, one must look elsewhere for very high temperatures. The steady state theory does not provide the requisite energy whereas the big bang theory does—during the initial moments of creation.

Finally there is the famous Olber's Paradox. In 1828 Olber realized the cosmologic implications of observing a dark sky at night. If the universe were really infinite in extent and light travelled in straight lines according to the rules of Euclidean geometry, then a fairly simple calculation shows that the sky should be infinitely, or at least very, bright even when the sun is facing the other side of the earth. For while the light intensity from an individual star *decreases* as the reciprocal of distance squared, the number of stars in an infinite universe *increases* as the distance squared. The two effects cancel each other, and therefore the observed intensity becomes proportional to the "radius" of the universe. For a steady state model, the intensity should be very great (even assuming some blockage of light by other stars). On the other hand, if the universe is finite in time and expanding without continuous creation, then one expects the night sky to be dark. Once again the steady state theory does not fare well against the observed phenomenon.

On the basis of this experimental data, the big-bang cosmology is assumed correct and we turn to a study of the initial moments. ■

(*To be continued*)

AN ANALOGY USING THE CELL

Martin M. Echols

The modern concept of the cell has provided us with a perfect example of a trine in nature. The trine is composed first of the cell nucleus, second the enveloping cytoplasm, and finally the substances released from the cell into the body as a whole. The cell is a system in which an abundance of material forms can give an analogical, ultimate expression to knowledges and ideas contained in Swedenborg's philosophical works and in the Word.

As one example, in his work entitled *Rational Psychology,* Swedenborg wrote of a series comprised of a pure intellect, a mixed intellect, and the consequent uses of thought. The pure intellect is that which "comprehends simultaneously that which thought or our rational mind comprehends successively" (132). Within the pure intellect therefore exist, simultaneously, both the causes and the effects of all things subsequent to it. It does not learn but already knows and is "as perfect in the embryo and infant as in the adult and old man" (134). The pure intellect is above the conscious mind and below the spiritual.

The next in the series is the mixed intellect. Within this intellect the ideas of thought are formed. But while both cause and effect are comprehended by the pure intellect at the same time, they appear in the mixed intellect in a successive order.

Finally, the things which are thought are put into action as forms