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ON CONTRADICTIONS BETWEEN TORAH AND SCIENCE: THE FIRST DAY OF CREATION— THE ORIGIN OF THE UNIVERSE

PERSPECTIVES

Our Sages constantly remind us that the Torah can be understood on many different levels (*shivim panim la-Torah*). Indeed, the Talmud and the midrashim constitute a rich store of profound allegorical interpretation of Biblical passages. However, in spite of the significance of these midrashim, Rashi and other commentators repeatedly stress the importance of the literal meaning of the Biblical text. Thus, the traditional Jewish viewpoint is that there is no contradiction between ‘conflicting’ interpretations of a Biblical passage: each interpretation has validity on its own level.

When analyzing the first chapter of the Book of Genesis, there has always been a certain reluctance to treat the text in its literal sense. Such reluctance is not surprising. Everyone with an awareness of science recognizes that there seem to be a large number of contradictions between the ‘facts’ as represented by scientific knowledge and the ‘facts’ as implied by a literal rendering of the first chapter of the Book of Genesis.

The question that is addressed in this essay is whether it is possible to understand the opening verses of the Book of Genesis in their literal sense. To answer this question, a detailed comparison is made between the Biblical text and current scientific evidence. This analysis shows that, despite the widespread notion to the contrary, there is in fact remarkable agreement between many passages of the Torah and recently discovered scientific knowledge.

As is well known, in all areas of science, important and often dramatic progress has taken place in recent years. However, it is

rarely appreciated to what extent this new-found knowledge can have a profound influence on our understanding of the first chapter of the Book of Genesis. Indeed, it is the thesis of this essay that modern science has provided us with a unique opportunity to discover new and deeper insights into numerous Biblical passages that otherwise seem enigmatic. Far from being the antagonist of the Torah, Science has become an important tool for its understanding.¹

In the next section, we list some of the questions that one might ask about the Biblical text relating to the First Day of Creation. This is followed by an account of the relevant scientific background. We then give an interpretation of the Biblical text based on scientific evidence. Each of these three elements requires some comment.

The questions that are raised are not the only ones that could be asked, nor is it implied that each question will seem compelling to every reader. These are the questions that are commonly asked—by some, in a sympathetic spirit of inquiry, whereas by others, as a provocative challenge to the Torah. To each of these questions, modern science has a new and illuminating explanation.

There is a tendency these days to disparage Science by emphasizing the transitory nature of scientific theory. However, every competent scientist can distinguish between the more speculative theories and those that are firmly established. It is the former that are short-lived and whose demise is regularly reported in the popular press, whereas the latter have an excellent record for longevity. For example, the theory of relativity and the quantum theory have had unqualified success since their inception in explaining hundreds of different phenomena. Such well-established theories are constantly being refined and extended, but they do not undergo fundamental revision. Of course, the empirical nature of Science precludes the possibility of the absolute proof of any theory. However, the chance that a well-established theory will eventually be overthrown is extremely slight.

It will be shown that current scientific evidence provides an answer to each of the questions that is asked about the Biblical text. This does *not* of course imply that the Book of Genesis can be read like a science textbook. But it is proposed that there exists a scientific explanation that is *consistent* with the text. Establishing this consistency is the task to which this essay is dedicated.

QUESTIONS

The events associated with the First Day of Creation are described in the opening five verses of the Book of Genesis. These verses contain several extremely problematic statements.

(i) First and foremost, we read (1:1) that God created the world. The Creation must surely be the most dramatic event in the history of the universe. Why, then, are there no signs *whatsoever* of its occurrence? Why cannot every scientist measure clear and undeniable evidence for the creation of the world? Indeed, let us openly admit that the very concept of Creation (יש מאין) contradicts well-known laws of nature, such as the law of the conservation of mass and energy.

(ii) We read (1:3) that God created Light. What light? The only known sources of light are the sun and the stars, some reflected light from the moon, and the light produced when one strikes a match or turns on a light switch. But on the First Day, there were no sun, no stars, and no Man. The nature of this light is thus a complete mystery that is never explained in any subsequent text. Nevertheless, it was considered so important that the entire First Day, one sixth of the story of Creation, is devoted to this enigmatic light.

(iii) We read (1:4) that God subsequently 'separated' the Light from the Darkness. Darkness is not a *substance* that can be separated from light. The word 'darkness' simply denotes the absence of light. If there is darkness, then there is no light: if there is light, then there is no darkness. Thus, there is no logical content to the notion of the 'separation' of Light from Darkness.

(iv) We read (1:2) that the world began in a state of 'chaos' (תהו ובהו). No indication whatever is given in the text as to the nature of this chaos. Just what was chaotic? And how was this chaos removed, if indeed it was removed?

(v) Finally, we read (1:5) that the entire complex series of events that are necessarily involved in the creation of the world occurred within the space of a single day. Everyone knows that the duration of cosmological/astronomical events is not measured in days nor even in years, but in millions and billions of years.

These are some of the questions that one may ask. We shall now present the current scientific evidence that relates to each of the questions raised in (i)–(v), assessing in detail these apparent contradictions between Torah and Science. It will be shown that, improbable as it may seem, scientific evidence discovered in recent years suggests an interpretation of the Biblical text that is free of ambiguities and completely consistent with current scientific knowledge.

COSMOLOGY

Cosmology is the branch of science that deals with the origin and development of the universe. This is one of the oldest of the sciences,

having been the subject of sustained interest for thousands of years in almost every civilization. However, until the present century, all cosmological studies were based on pure speculation, with little if any scientific basis. It is important to realize that this situation had not significantly improved even by the middle of the 20th century. Professor Steven Weinberg, a Nobel laureate from Harvard University, writes that “in the 1950’s, the study of the early universe was widely regarded as not the sort of thing to which a respectable scientist would devote his time . . . there simply had not existed an adequate observational and theoretical foundation on which to build a history of the early universe.”²

The approach to cosmology that was fashionable in the 1950’s was based on the idea that the universe we observe today has always existed and will always exist in essentially its present form. Indeed, the assumed constancy of universe is consistent with the results of thousands of years of continuous astronomical observation, which has produced a record of a fixed and unchanging sky, except of course for the gradual rotation of the stars around the heavens as the earth revolves around the sun once each year. The pattern of stars and constellations that we see today is virtually identical to that recorded by the star-gazers of ancient civilizations. This tradition of stellar quiescence naturally suggests the idea of a constant universe and may have played its part in the acceptance of such an idea—all without adequate scientific basis.

THE BIG-BANG THEORY

In 1946, George Gamow and his collaborators proposed an entirely different theory of cosmology.^{2, 3} The main features of this revolutionary theory are listed in the accompanying Table, in which time is measured in billions of years.⁴ The present time is denoted by ‘15’ because, according to the Gamow theory, the universe began 15 billion years ago. At that time, denoted by ‘0’ in the Table, there suddenly appeared out of nothing an enormous source of energy, called the ‘primeval fireball’ but popularly known as the ‘big bang,’ hence the name ‘big-bang theory.’ The sudden appearance of the primeval fireball marked the beginning of the universe in the sense that before the big bang, nothing at all existed. Thus, the big bang is the precise realization of *יש מאין*.

We put aside for the moment the all-important question of where the primeval fireball came from and proceed to describe some basic aspects of the theory. In particular, how did the primeval fireball develop into the world as we know it? Our present world is

composed of ‘matter’ (in the form of atoms and molecules) which is the basic constituent of everything we see, ranging from stars and galaxies to oceans and trees and animals. From where did all this matter come?

The answer is given by the famous formula of Einstein’s theory of relativity,

$$E = Mc^2,$$

where E denotes energy, M denotes matter and c denotes the speed of light. This formula states that matter can be converted into energy. Moreover, because of the large value of the ‘exchange rate’ c^2 , a little bit of matter suffices to produce an enormous amount of energy. This matter-to-energy conversion is not merely a hypothetical possibility, but forms the basis for nuclear energy, whose powerful bombs devastated Hiroshima and Nagasaki but whose peaceful use provides electric power for tens of millions of families. The big-bang theory utilizes the fact that Einstein’s formula can work both ways: not only can matter be converted into energy, but energy can also be converted into matter. Although it requires a vast amount of energy to produce only a little matter, the amount of energy present in the primeval fireball was so enormous that it was the source of all the matter that now exists in the entire universe.

THE BIG-BANG THEORY

Event	Time (billions of years)
The present	15
Formation of atoms and molecules Universe suddenly becomes transparent Light begins shining and fills entire universe	0.001
Sudden appearance of primeval fireball Beginning of the universe Big bang—י׳ מאיך	0

We now come to a most important event which occurred shortly after the big bang, at the time denoted by ‘0.001’ in the Table. In order to understand this event, some background information is necessary. The most familiar form of matter is an atom, or a group of atoms called a molecule. However, when matter was initially formed, immediately after time zero, it did not exist in the form of atoms. The

enormous temperature of the primeval fireball would have instantly disintegrated any atom. At first, matter existed in a different form called a 'plasma.' The important distinction between these two forms of matter is that an atom is electrically neutral, whereas a plasma consists of positively and negatively charged particles. The properties of charged particles cause a plasma to 'trap' light and to prevent its free passage. Since the universe initially contained a plasma, the light of the fireball was trapped and could not 'escape' from the plasma to be 'seen.' Therefore, the universe would have appeared dark to an outside observer even though it was filled with the light of the fireball.

The very hot primeval fireball cooled extremely rapidly. By the time 0.001 (see the Table), it had cooled sufficiently to permit the charged particles of the plasma to form atoms. The formation of atoms from the plasma was a vitally important event, being crucial for the universe to develop into its present form.

In contrast to a plasma, any region of space filled with free atoms and molecules is completely transparent. One need only think of the transparent atmosphere which is composed of molecules of air (mainly nitrogen and oxygen). Light shines freely through the atmosphere: from the surface of the Earth, one clearly sees the sun, the moon, and the distant stars and galaxies. Therefore, when the plasma was suddenly transformed into atoms and molecules 15 billion years ago, the light of the fireball was no longer trapped by the plasma. Instead, the light began to 'shine' visibly and it soon filled the entire universe, as it still does to this very day.

This concludes our very brief description of the main features of the big-bang theory of George Gamow. As with any scientific theory, the criterion for acceptance is that the predictions of the theory must be confirmed. The most striking prediction of the big-bang theory is surely that the universe is filled with light, dating back nearly 15 billion years to the very origins of time. This light, called 'electromagnetic radiation' by the scientist, has very special properties (which need not concern us here) that make it easy to distinguish from other sources of interstellar radiation. However, at the time that Gamow propounded his theory, this predicted radiation had never been seen.

It is easy to explain why the predicted radiation was not seen. The primeval fireball was originally extremely hot and contained an enormous concentration of energy. However, with the passing of time, the fireball cooled and expanded, with the result that the radiant energy spread out. Today, after 15 billion years have passed, the energy of the fireball is very thinly spread and its radiation is so extremely weak that it was technically impossible to detect with the available scientific apparatus.

The situation regarding the big-bang theory in its early days can be summarized as follows. This theory of cosmology was completely different from generally accepted ideas. Moreover, for technical reasons, its dramatic prediction of the existence of a special radiation that fills the entire universe could not be tested. Therefore, it is not surprising that the big-bang theory was not taken seriously by the scientific community.

CONFIRMATION OF THE THEORY

In the years following the Second World War, major technological breakthroughs occurred in scientific instrumentation, with radiation detectors being improved a hundredfold and more. As a result, many measurements that could not be performed with the technology available in the 1940's became possible by the 1960's. In particular, it became technically feasible to detect the extremely weak radiation predicted by the big-bang theory.

In 1965, two American scientists, Arno Penzias and Robert Wilson of the Bell Telephone Research Laboratories, were using an extremely sensitive antenna to measure galactic radio waves. While testing their antenna, they observed some very weak unexpected radiation that seemed to be coming simultaneously from all directions in outer space. It was soon realized that this radiation was precisely what was predicted by the big-bang theory.

Since Penzias and Wilson first announced their findings, many other scientists have confirmed their measurements. At present, there is not the slightest doubt that this fundamental prediction of the big-bang theory has become a scientifically established fact. Moreover, other key predictions of the big-bang theory have also been confirmed, such as the relative amounts of hydrogen and helium in the universe. Because of the confirmation of all its predictions, the big-bang theory has become the accepted theory of cosmology, with the abandonment of all competing theories. Today, scientists carry out research in cosmology only within the framework of the big-bang theory. The final mark of recognition of the validity of the big-bang theory occurred in 1978, when Arno Penzias and Robert Wilson were awarded the Nobel Prize in Physics for their fundamental discovery. Unfortunately, George Gamow could not share in this award because he had died in 1968 and the rules of the Nobel Prize do not permit posthumous awards.

It would be difficult to overestimate the importance of the Penzias-Wilson discovery. Professor Steven Weinberg calls it "one of the most important scientific discoveries of the 20th century."⁵ One

can well understand the superlatives used by Weinberg. The big-bang theory has totally altered our conception of the origins of the universe.

THE BIBLICAL TEXT

It is now time to return to our initial program, a comparison of the Biblical text and current scientific knowledge. Accordingly, we shall examine critically each of the five points listed at the beginning of this essay.

(i) *Creation*

The creation of the world has now become accepted by all leading cosmologists. The reason for this widespread acceptance is that by making appropriate measurements, every scientist can see clear and convincing evidence in support of the conclusion that creation indeed occurred.

It is instructive to quote a few statements made by the cosmologists who stand at the very head of their profession. Professor Stephen Hawking of the University of Cambridge writes, "The actual point of creation lies outside the scope of presently known laws of physics."⁶ Professor Alan Guth of the Massachusetts Institute of Technology and Professor Paul Steinhardt of the University of Pennsylvania write, "The instant of creation remains unexplained."⁷ Professor Joseph Silk of the University of California at Berkeley chose the following title for his recent book on cosmology: *The Left Hand of Creation*.⁸ And finally, a recent scientific article published in one of the foremost international journals of physics carries the following title: "Creation of the Universe from Nothing."⁹

The term 'creation' has clearly left the private preserve of the Biblical scholar and has entered the lexicon of Science. Indeed, creation plays a leading role in the current scientific discussion of cosmology.

We now turn to the central issue—the vital question of what caused the sudden appearance of the primeval fireball that heralded the creation? As stated above, in the words of some of the world's leading cosmologists, the creation of the universe is "outside the scope of presently known laws of physics"⁶ and "remains unexplained."⁷ In contrast to the Scientist, the believing Jew does have an explanation for what caused the creation of the world, an explanation that is written in the very first verse of the Bible: "In the beginning, God created. . . ."

(ii) *The Light*

Cosmologists now recognize that the sudden unexplained appearance of the primeval fireball is the creation of the universe. The Biblical expression “Let there be Light” (יְהִי אֹרֶךְ) may therefore be understood as designating the creation of the primeval fireball—the big bang—that signals the creation of the world. All the matter and energy that exists today throughout the universe results directly from this ‘light.’ Note in particular that there were not two separate unconnected creations on the First Day—the World and the Light—but only one.

(iii) *Separation of the Light*

The big-bang theory predicts that the sudden transformation of the plasma into atoms shortly after the creation caused the radiation (‘light’) of the primeval fireball to ‘separate’ from the dark matter (‘decouple’ is the scientific term) and shine freely throughout the universe. This decoupled radiation was eventually detected 15 billion years later by Penzias and Wilson.

(iv) *Tohu va-Vohu*

Important developments have occurred in the big-bang theory since 1980 which fall under the general heading of ‘the inflationary universe,’ proposed by Guth and Steinhardt. A recent (1984) article summarizing these new findings contains the following words: “The universe began [again without explanation] in a random chaotic state.”⁷ A recent (1983) book on cosmology⁸ discusses at length the phenomenon of the ‘primordial chaos’ and its important cosmological implications. This discussion appears in the section of the book called “Primeval Chaos” which is part of the chapter entitled “Chaos to Cosmos.” It lies beyond the scope of this essay to explain the nature of this chaos and its importance, but it should be emphasized that the role of chaos in the development of the very early universe has become a major subject of cosmological research. The relevance of this to our discussion is clear: the Hebrew expression for ‘chaos’ is *tohu va-vohu*.

(v) *Creation in a Single Day*

It is a common fallacy to believe that because cosmological changes occur extremely slowly at the present time, it must have always been so. Indeed, this is precisely the philosophy behind the now-disproved earlier theories of cosmology. By contrast, according to the modern big-bang theory, a long series of dramatic cosmological changes

occurred within an extremely short time at the very beginning of the universe. This point was brought home very forcibly by Professor Steven Weinberg by his choice of title for his popular book on modern cosmology: *The First Three Minutes*.² It takes Professor Weinberg 151 pages of text and diagrams to describe the momentous cosmological changes that took place in our universe during a mere three minutes.

In conclusion, a revolution has occurred in cosmology during the last two decades, a revolution that augurs well for the believing Jew who takes seriously the Biblical text. Moreover, it is possible to show¹⁰ that the remarkable consistency between Science and Torah exhibited here is not limited to cosmology, but extends to other areas of science as well.

SUMMARY

A most appropriate summary to this essay can be found in the words of Professors Guth and Steinhardt, who comment that "from a historical point of view, probably the most revolutionary aspect" of the modern theory of cosmology is the claim that matter and energy were literally created. These cosmologists emphasize that "this claim stands in marked contrast to centuries of scientific tradition in which it was believed that something cannot come from nothing."⁷

In short, recent scientific discoveries regarding the cosmos have produced a picture of the origins of the universe that is in striking agreement with the simple words that appear in the opening passages of the Bible.

NOTES

1. This point has been decisively demonstrated in several recent works, such as the journal *Proceedings of the Association of Orthodox Jewish Scientists* and the important collection of essays edited by A. Carmell and C. Domb, *Challenge* (Feldheim, Jerusalem: 1978). Several of these essays adopt an approach quite similar to that presented here.
2. S. Weinberg, *The First Three Minutes* (Andre Deutsch and Fontana, London: 1977), pp. 13-14.
3. G. T. Bath, *The State of the Universe* (Oxford University Press, Oxford: 1980), Chap. 1.
4. The term 'billion' is used here to denote 1000 million, following American and British usage. A continental European or an Israeli would prefer the term 'milliard' for this number.
5. S. Weinberg, *loc. cit.*, p. 120.
6. S. W. Hawking and G. F. R. Ellis, *The Large Scale Structure of Space-Time* (Cambridge University Press, Cambridge: 1973), p. 364.
7. A. H. Guth and P. J. Steinhardt, "The Inflationary Universe," *Scientific American*, Vol. 250 (May 1984), p. 102.
8. J. D. Barrow and J. Silk, *The Left Hand of Creation* (Heinemann, London: 1983).
9. A. Vilenkin, *Physics Letters*, Vol. 117B (1982), pp. 25-28.
10. N. Aviezer, *And There Was Evening, And There Was Morning* (Feldheim, Jerusalem: 1989).