Dr. Schroeder: The Science of G-d (SOG)

מכות כד: בא חבקוק והעמידן על אחת שנאמר (חבקוק ב') וצדיק באמונתו יחיה
Chavakuk established all *mitzvos* on one principle: "The tzadik lives by his faith"
DRAFT. Jonathan S. Ostroff

כ'.סיון.תשפ"ג
Friday, June 9, 2023
Revised Monday, June 12.

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אֲנִי מַאֲמִין בֶּאֱמוּנָה שְׁלֵמָה שֶׁהַבּוֹרֵא יִתְבָּרַךְ שְׁמוֹ הוּא **בּוֹרֵא** ו**מַנְהִיג** לְכָל הַבְּרוּאִים וְהוּא לְבַדּוֹ עָשָׂה וְעוֹשֶׂה וְיַעֲשֶׂה לְכָל הַמַּעֲשִׂים:
I believe with complete faith that the Creator, blessed is His Name, is the Creator and Guide of all created things, and He alone has made, does make, and will make all things.

1 Purpose of this article

I received the following email:

> June 4, 2023. Dear Dr. Ostroff ... Rabbi ... reached out to you earlier to set a time to speak with me. He wants to make sure that my views on Torah and science are kosher. ... Regarding origin of life and evolution, I hold to Intelligent Design and/or theistic evolution, that G-d alone generates all life, and directly supervises the entire process of development and any speciation. ... Regarding the origins of the universe, I believe much of Big Bang cosmology really just describes what the Torah is saying anyway (i.e. a point of origin, Creation from light/radiation) and I outlined my views here. If you are familiar with Dr. Gerald Schroeder's calculations, I have similar views that we are literally in 5783, and simultaneously the universe might appear to be billions of years old due to perspective and relativistic effects. ... I would really love to get your feedback ... Thank you so much for your time and consideration.

This article is a response, in particular, to Dr. Schoeder's approach of *theistic evolution*, i.e., that observant Jews can accept the neo-Darwinian account of billions of years of evolution via random and natural processes, while at the same time asserting that G-d is guiding this process.[1]

My belief is that it is perplexing to assert that a proces that leading academics consider unguided based on their scientific understanding of nature -- is in fact guided by G-d. Does the book of Genesis really describe an *unguided* process that is *guided*? Theistic evolution also violates fundamental principles of Judaism. Harav Shlomo Miller, *Shlita*, wrote:

> [A]ll of the laws of nature which prevail today were first established at the end of the six days of creation when Hashem terminated the creative process as represented by the day of Shabbos when "He said to His world, enough".[2] In reality, the laws of nature which existed during the six days of creation have no parallel to those which we perceive today. Our sages have already stated "two arose on the bed and four descended" meaning that the birth of Kayin and Hevel happened immediately after their conception on the sixth day of creation.[3]

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[1] Richard Dawkins book on evolution is titled *The Blind Watchmaker*. There might be the appearance of design, he asserts, but the watchmaker is "blind", i.e. random mutation and natural mutation are unguided processes.

[2] This saying is based on the Talmud in Chagiga 12a – " Rav Yehuda stated in the name of Rav, at the time that Hakadosh Baruch Hu created the world, it continued to expand like two clues of warp until Hakadosh Baruch Hu rebuked it and brought it to a standstill as it states "the pillars of heaven were trembling, but they became astonished at his rebuke" (Iyov 26:11) This accords with Raish Lakish's statement; the verse states "ani E-l Shakai" (Bereishis 35:11), "*ani hu she'amarti laolam dai*" which means "I am the one who has instructed my world, enough". In other words, before the culmination of the six days of creation, there was no limit to the expansion of creation and thus, no clearly delineated physical laws, but when Hashem finally decided that there should be fixed boundaries, he "told" the universe "enough" and established the final limitations of physical law.

[3] Rav Miller continues "opinions in these matters are absolute heresy". Translation of Rav Miller's letter is by Rabbi Simcha Coffer. Rabbi Coffer also writes. *Rav Yochanan bar Chanina* said, the [sixth] day consisted of 12 hours: in the first hour, his [Adam's] dust was gathered, in the second, it was made into a shapeless mass, in the third, his limbs were formed, in the fourth, he was infused with a soul, in the fifth, he stood on his legs, on the sixth, he named names [of the animals], on the seventh, Chava was established as his mate, in the eighth, two arose onto the bed and four descended, on the ninth, he was commanded not to eat from the tree, on the tenth, he sinned, on the eleventh, he was judged and on the twelfth, he was expelled from the garden of Eden and went along his way... *(Sanhedrin 38b)* Accordingly, "four descended" would seem to imply *Kayin* and *Hevel* and in fact, this is precisely how the *Tur* (see *Tur al haTorah)* understands this Gemara. See also *Aderes Eliyahu* on *Bereishis 4:2* and *Bereishis Rabbah 22:3.* However, *Tosfos* maintains that the second sibling that was born was *Kayin's* twin sister, not *Hevel* Cf. *Tosfos* ad loc. s.v. *viyardu arba'ah and Maharsha.*

In other words, Creation is a *meta-physical* process, not a process that finds expression in current laws of nature and thus cannot be defined by it. During the *sheyshes yimey bereishis*, the laws of nature were entirely different from those that exist today. This is self-evident from the Torah and can be gleaned from *Chazal*. Furthermore, this has been the collective *mesorah* of all Jews throughout the. When a Jew makes *kiddush* Friday night he is specifically proclaiming the truth of this principle. It is evident from Torah and Chazal that the period of creation ended when the first Shabbos came and therefore any claim that present laws of nature can duplicate the order of creation refutes a basic principle of the Torah.

2 The "modern" view of Genesis

The historical accuracy of the biblical description of the origin of the cosmos and of life itself has been the subject of controversy and reinterpretation for millennia. The Reform movement's commentary to to *Breishis* asserts that the Bible "has a great deal to tell about God's relationship to the world and about human beings and their destiny," but believes that the opening chapters are "unscientific, antiquated myths" that may be approached "in the same manner as one approaches poetry." (Plaut, The Torah, rev. ed. (2005), at 6.) *Etz Hayim*, the Torah commentary published by the Conservative movement (2001) holds similarly[4]: "The opening chapters of Genesis are not a scientific account of the origins of the universe. The Torah is a book of morality, not cosmology."

This rejection of the historicity of Genesis is based on the unproven assumption that the *origin sciences* (as opposed to the operational sciences) are if not incontrovertible -- at least beyond a reasoable doubt.

The scientific enterprise in modern times is thoroughly atheistic; it therefore promotes an atheistic approach to the origin of the universe via (1) Cosmic Evolution (Big Bang Cosmology), (2) Chemical Evolution (life from dead chemicals) and (3) Biological Evolution (neo-Darwinism, survival of the fittest, random mutation and natural selection). Almost all the most prestigious academics working in the origin scientists believe that we are here by unguided processes that did not have us in mind. Harvard biologist Gaylord Simposn wrote:

> "Man is the result of a purposeless and materialistic process that did not have him in mind".[5]

The eminent physicist Steven Weinberg is often quoted by Dr. Schroeder:

> Steven Weinberg, who died in July [2021] at the age of 88, was not only a Nobel laureate physicist but also one of the most eloquent science writers of the last half century. His most famous (or perhaps infamous) statement can be found on the second-to-last page of his first popular book, *The First Three Minutes*, published in 1977. Having told the story of how our universe came into being with the big bang some 13.8 billion years ago, and how it may end untold billions of years in the future, he concludes that whatever the universe is about, it sure as heck isn't about us. "*The more the universe seems comprehensible*," he wrote, "*the more it also seems pointless*".[6]

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[4] Quoted from Roger Price author of "When Judaism meets Science".
[5] George Gaylord Simpson, The Meaning of Evolution: A Study of the History of Life and of Its Significance for Man, Yale University Press, New Haven, 1967, p345.
[6] https://www.scientificamerican.com/article/learning-to-live-in-steven-weinbergs-pointless-universe/

At the same time, the same author (Steven Weinberg) writing in that same text *The First Three Minutes* states:

> "Nevertheless, there is one great uncertainty that hangs *like a dark cloud* over the standard model. Underlying all the calculations described in this chapter is the *Cosmological Principle*, the assumption that the universe is *homogenous* and *isotropic*. (By homogenous we mean that the universe looks the same to any observer who is carried along by the general expansion of the universe, wherever that observer may be located; by "isotropic" we mean that the universe looks the same in all directions to such an observer.) ... *However, we have no evidence that the Cosmological Principle was valid at earlier times*".[7]

A fundamental cornerstone of the Friedmann-Lemaitre space-time solution to Einstein's equations used in Big Bang Cosmology is the *Cosmological Principle*. However, this cornerstone is a totally unproven assumption. In fact, we cannot have any such experimental evidence for homogeneity because nobody has yet been to the distant galaxies to verify its correctness! No wonder the resulting uncertainty "hangs like a dark cloud" over the theory.

Not all theories promoted as "science" are as solid as Newtonian mechanics, Maxwell's laws of Electromagnetism or Quantum Mechanics. These *Operational Sciences* describe how the universe operates today; they are based on empirical testing that can get us to the moon or map the human genome. Good technology is based on such empirical observations and testing. The stability and rationality of nature is guaranteed by the Creator of the Cosmos, thus making the operational sciences possible.

By contrast, the *Origin Sciences* attempt to explain via chance and naturalistic processes how the cosmos and the marvels of life originated. How did the first cell originate? How did the information in the human genome originate? How did creatures with no eyes develop eyes? How did creatures with no brains develop brains? How did we get from a fish to a philosopher? How did the solar system or galaxies originate? How did the cosmos, fine-tuned for life and discovery, originate?

The problem is that the Origin Sciences include implausible naturalistic accounts using chance and naturalistic explanations. They are speculative, and thus suspect, because they are based on *untested foundational assumptions*, *vast extrapolations* to an open-ended and unobservable past, and the need to postulate unobserved *hypothetical entities* to save the theories from disconfirmation from stubborn anomalies in the data.

> Our willingness to accept scientific claims that are against common sense is the key to an understanding of the real struggle between science and the supernatural. We take the side of *science* in spite of *the patent absurdity of some of its constructs*, in spite of its failure to fulfill many of its extravagant promises of health and life, in spite of the tolerance of the scientific community for unsubstantiated just-so stories, because we have a prior commitment, a commitment to materialism.[8]

There is thus no need to seek the subjective tendency of bending the Genesis account in the Bible to match these origin sciences.

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[7] Steven Weinberg, *The First Three Minutes*: *A Modern View of the Origin of the Universe*, Basic Books, New York, 1993. pages 119-120.

[8] Richard Lewontin, Alexander Agassiz Professor of Zoology at Harvard, *Billions and Billions of Demo*ns, New York Review of Books, Vol. 44, 1997. Emphasis added in this and most other sources.

The actual emperical evidence of modern science is that we live in world buzzing with Plan and Purpose. The details may be found elsewhere[9], but in this article we review one aspect of Dr. Gerald Schroeder's "theistic evolutionary" claims, viz. the conflict beteen the "scientific" age of the universe involving billions of years of evolution and the six-day meta-natural Creation Week.[10]

3 Dr. Schroeder's science: 6 days is 15 billion years

I admire the work Dr. Schroeder has done in *kiruv*. He is a firm believer in the G-d of the Torah, the Creator and Guide of the universe. Our critique below is thus with "hidden love".[11]

Dr. Schroeder's position was first set forth in *Genesis and the Big Bang: The Discovery of the Harmony Between Modern Science and the Bible* published in 1991, and later in *The Science of God: The Convergence of Scientific and Biblical Wisdom* (1997). He writes that "G-d runs this world," and when appropriate, "G-d steps in and redirects the way" [SOG1997, page xiii]. The "first Divine creation was wisdom" and he seeks to use "that wisdom" to "explore the workings of G-d in our magnificent universe" [SOG1997, pages xiii-xiv.) This is what he calls "the science of G-d" [SOG1997, page xiv.].

Please see the footnote to this sentence for his various publications quoted in this article.[12] In 1997, I had a brief correspondence with Dr. Schroeder, and it is this latter 1997 book (and its later editions) that we address in this article.

How can the Bible and Science both be right? Let's start with cosmology. The Bible says God created the universe in six creation days with the passage of less than 6,000 years since then. Science currently estimates the visible universe to be about 13.8 billion years old, give or take a few billion.

Dr. Schroeder claims he can show us how these two contradictory claims can be reconciled based on science itself (e.g. Einstein's theory of relativity and Big Bang Cosmology).

Dr. Schroeder reconciles the conflict by explaining that the six days of the Bible refer to a "cosmic clock" that measures time via the redshift[13] in an electomagnetic remant of the Big Bang

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[9] See https://toriah.info/evolution/.

[10] Theistic evolutionists make the puzzling claim that the *unguided* natural processes of evolution are actually *guided* by G-d.

[11] See the Ramban's commentary in Chumash in response to the Ibn Ezra.

[12] My paper copy is the 1997 version. There is a later updates with minor changes: Schroeder, Gerald L.. The Science of God: The Convergence of Scientific and Biblical Wisdom (pp. 42-43). Free Press, 2005. Kindle Edition. Unfortunately, the mathematical equations in the Kindle version are jumbled; so we use the 1997 version for the mathematical development. The basic problems will be the unchanged. I will use SOG1997 when quoting the 1997 version and SOG2005 when quoting the later version. There is also a later version of the mathematical calculations at the *Aish Hatorah* site: https://aish.com/the-age-of-the-universe-one-reality-viewed-from-two-different-perspectives. Presumably, this update was needed when the age of the universe changed from 16 billion years in 1997 to about 13.8 billion years currently. What is a few billion years among friends?

[13] The light from galaxies is shifted towards the red end of the electromagnetic spectrum suggesting that most galaxies are racing away from us. This is just like when an ambulance comes towards you the wavelength of the siren is

(the CMB, i.e., Cosmic Microwave Background radiation). This is now redshifted by a factor of a trillion (10^{12}) from the period of "quark confinement" when early forms of matter such as protons and neutrons (supposedly[14]) first began to form. This "cosmic clock" ticks six days at earlier epochs for each of the trillions of days measured here on Earth . So, according to the author, Genesis is not only consistent with cosmology, but the Torah **predicts**[15] that the universe is billions of years old! Dr. Schroeder writes:

> In the following chapters, I attempt to avoid the subjective tendency of bending Bible to match science or science to match Bible. To accomplish this goal, I cite only scientific opinions appearing in leading science journals. The theological sources are primarily restricted to works that predate by centuries the discoveries of modern science. Those will be primarily the Hebrew Bible, the Talmud (a collection of commentaries on the Hebrew Bible redacted in two stages, in the years 300 and 400), and the thirteenth-century kabalist, *Nahmanides*. Nahmanides is not only the leading kabalistic commentator on the Book of Genesis (and the entire Torah), but also one of the earliest earliest kabalists whose commentary is written in a readily understandable Hebrew. [SOG2005, page 19]

Contra Dr. Schroeder, just as we will *not* find a six day "cosmic clock" in the leading science journals, we we will also *not* find a universe that is billions of years old in the writings of the kabalist Nahmanides (*Ramban*). Dr. Schroeder writes[16]:

> There is a simple answer to the problem of a scientifically old and biblically young universe, an answer that has within it the core of a complex truth. Time as described in the Bible may not be the same as we know time today. We find a hint for this in the 2,900-year-old Book of Psalms: "A thousand years in Your sight are as a day that passes, as a watch in the night" (Ps. 90:4). Perhaps from a biblical perspective the six days of Genesis include the fifteen billion years we earthbound mortals estimate to be the span of time since the beginning of time, just as a watch in the night might include a thousand years. That makes sense…if you believe Psalm 90!

Let us follow Dr. Schroeder's puzzling claims in his own words. The title of Chapter 3 of SOG is "The Age of Our Universe: Six Days and Fifteen Billion Years". In this chapter and the next, we find the description of the two clocks, the clock of the Biblical Six Days of Creation and the scientific clock of Fifteen Billion Years based on Einstein's Theory of Relativity and Cosmic Background Radiation of Big Bang Cosmology.

"To grasp the full meaning of Psalm 90, we need a deeper understanding of the universe than casual observation reveals".[17] SOG postulates "golden apples" indicating that both clocks are supported by science.

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shortened and the pitch is higher (in light waves that would be a blueshift). When the ambulance rushes away from you the pitch is lowered because the wavelength of the sound are stretched out ("redshift"). Since all the galaxies are receding, in an earlier era we must all have been closer together in a smaller volume.

[14] See Andrew Pickering, *Constructing Quarks*, University of Chicago Press, 1984, for why this theory is in need of re-evaluation.

[15] Dr. Schroeder actually implies that Genesis is **predicting** the age of the universe as 15 billion years: "To learn the duration of each Genesis day as viewed from our perspective of time, we integrate the equation and solve this integrated form for each of the six days of Genesis… The sum of the durations of all six days is a *prediction* of the age of the universe" .[SOG2005, p66].

[16] My paper copy is the 1997 version, but there are later updates with minor changes: Schroeder, Gerald L.. The Science of God: The Convergence of Scientific and Biblical Wisdom (pp. 42-43). Free Press, 2005. Kindle Edition. Unfortunately, the mathematical equations in the Kindle version are jumbled; so we use the 1997 version for the mathematical development. The basic problems will be the unchanged.

[17] SOG1905, p.43.

> "THE SECOND GOLDEN APPLE: UNDERSTANDING TIME. In 1915, Einstein published a description of nature which revealed an extraordinary, and seemingly quite unnatural fact: the rate at which time passes is not the same at all places".[18]
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> THE FOURTH GOLDEN APPLE: A UNIVERSAL CLOCK. … Just after the big bang, the universe was a concentrated hot plasma with nearly identical energies throughout. The relative passage of time varied only slightly, if at all, among its components. But as the universe expanded and cooled, vastly different local gravities and velocities evolved, having vastly different rates at which local proper times flowed. For our understanding of Genesis time, we must maintain the undifferentiated frame of reference that pervaded the universe at its beginning. The lights we see in the heavens originate with energy released in stellar and galactic nuclear reactions. But there is another source of cosmic radiation, one that has been present since the creation of the universe. That is the radiation remnant, the echo as it were, of the big bang. This cosmic microwave background radiation (CMBR) fills the entire universe, unrelated to any particular source. Discovered by Arno Penzias and Robert Wilson in 1965, it is the only source of radiation that has been present and ubiquitous since the creation. CMBR frequency forms the basis of cosmic proper time, the biblical clock of Genesis. … Concepts of cosmic proper time relative to the expansion of the universe and its perceived age have been presented in such prestigious peer-reviewed journals as *Nature* and the *American Journal of Physics*".[19]

Dr. Schroeder implies that there is a 6-day "cosmic clock" supported by the scientific literature. He writes:

> A more accurate, though cumbersome, translation of Genesis 1:2 is: "And the earth was in a state of chaos but filled with the building blocks of matter." Since biblical time takes hold with the appearance of matter, the biblical clock starts at *bohu*, that instant just after the big bang when stable matter as we know it formed from energy.
>
> The age of all matter in the universe dates back to *bohu*, the *moment of quark confinement*.

Why the Biblical term *bohu*, is the moment of a speculative theory called quark confinement remains a mystery.

> We know the temperature and hence the frequency of radiation energy in the universe at quark confinement. It is not a value extrapolated or estimated from conditions in the distant past or far out in space. It is measured right here on Earth in the most advanced physics laboratories and corresponds to a temperature approximately a million million times hotter than the current 3°K black of space. That radiant energy had a frequency a million million times greater than the radiation of today's cosmic background radiation. The radiation from that moment of quark confinement has been stretched a million-million fold. Its redshift, z, as observed today is 10^{12}. That stretching of the light waves has slowed the frequency of the cosmic clock—expanded the perceived time between ticks of that clock—by a million million. "This also applies to proper rates of events as one sees by the application of a sequence of Lorentz time-dilation factors." Those are solid values in physics.
>
> To measure the age of the universe, we look back in time. From our perspective using Earth-based clocks running at a rate determined by the conditions of today's is correct for our local view. *The Bible adopts this Earthly perspective, but only for times after Adam*. The Bible's clock before Adam is not a clock tied to any one location. It is a clock that looks forward in time from the creation, encompassing the entire universe, a universal clock tuned to the cosmic radiation at the moment when matter formed. That cosmic timepiece, as observed today, ticks a million million times more slowly than at its inception. The million millionfold stretching of radiation since *bohu* caused that million-million-to-one ratio in this perception of time. This cosmic clock records the passage of one minute while we on Earth experience a million million minutes. The dinosaurs ruled the Earth for 120 million years, as measured by our perception of time. Those clocks are set by

[18] SOG1905, p.47.
[19] SOG1905, pages 50 to 53.

> the decay of radioactive nuclides here on Earth and they are correct for our earthly system. But to know the cosmic time we must divide earth time by a million million. At this million-million-to-one ratio those 120 million Earth years lasted a mere hour. That's the peer-reviewed physics and the biblical tradition of this discussion. Now for the modern theology. What does all this mean for the age of the universe? In terms of days and years and millennia, this stretching of the cosmic perception of time by a factor of a million million, the division of fifteen billion years by a million million reduces those fifteen billion years to six days![20]

In the above quote, Dr. Schroeder writes that reputable scientific sources refer not only to earth bound clocks that have ticked 15 billion years, but at the same time to a "cosmic clock" that has ticked six days: "The Bible's clock before Adam is not a clock tied to any one location. It is a clock that looks forward in time from the creation, encompassing the entire universe, a universal clock tuned to the cosmic radiation at the moment when matter formed. That **cosmic timepiece**, as observed today, ticks a million million times more slowly than at its inception", i.e. **it ticks 6 days** while the clocks we measure here on earth tick 15 billion years". Moreover, "The clock of the universe is the light of the universe. Each wave of light is a tick of the **cosmic clock**. The frequencies of light waves are the timepieces of the universe (references **11** and 12 to 14)".[21]

As Dr. Schroeder writes: "*with the insights of Albert Einstein, we have discovered in the six days of Genesis the billions of years during which the universe developed*." [SOG1997, page 71].

We thus expect to find this 6-day "cosmic clock" in the scientific literature. I checked reference (**11**) in SOG: C. Misner, K. Thorne, and J. Wheeler, *Gravitation*, W. H. Freeman, San Francisco, 1971, pp. 659, 776.

This standard text on Gravitation has no reference to a 6-day "cosmic clock", not on page 659 nor on page 776. This putative clock does not exist in reputable scientific references. It is an invention cherry picked to obtain a desired result. On this basis alone, the resolution offered by Dr. Schroeder fails.

In the next section we will describe the actual global and uniform clock used by Cosmologists for the age of the universe. Thereafter, we will further analyze the "cosmic clock" invented in SOG.

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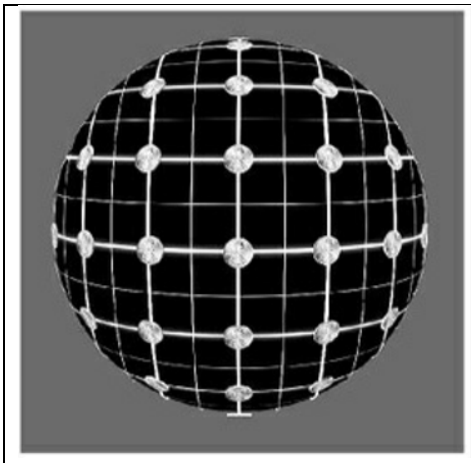
[20] Schroeder, Gerald L.. The Science of God: The Convergence of Scientific and Biblical Wisdom (p. 58). Free Press. Kindle Edition.

[21] Schroeder, Gerald L.. The Science of God: The Convergence of Scientific and Biblical Wisdom (p. 50). Free Press. Kindle Edition.

4 What Clock is used by Cosmologists?

Figure 1: Age of the Universe in Cosmology



Above: Figure 8.3 in Greene, Brian. *The Fabric of the Cosmos* (p. 234). Knopf Doubleday Publishing Group.

Space visualized via an expanding balloon: If evenly spaced pennies are *glued* to the surface of a balloon as it expands, the view seen by any one penny is the same as that seen by any other. This aligns with the belief that the view from any galaxy in the universe, on average, is the same as that seen from any other. As the sphere expands, the distances between all pennies increase. When astronomers speak of the universe's age, they are seeking something universal—they are seeking a measure that has the same meaning everywhere. The uniformity of change throughout space provides a way of doing that. In fact, the uniformity of the microwave background radiation provides a ready-made test of whether you actually are moving with the cosmic flow of space. The clocks we are now discussing are not moving through space at all. Just as each penny is glued to one point on the balloon and only moves relative to other pennies because of the swelling of the balloon's surface, each galaxy occupies one region of space and, for the most part, only moves relative to other galaxies because of the expansion of space. *And this means that, with respect to space itself, all the clocks are actually stationary, so they tick off time identically*

When scientists calculate that the age of the cosmos is about 13.8 billion years they use a standard clock that ticks at the same rate for all those billions of years. Cosmologist Brian Greene writes:

> If relativity teaches us that the passage of time depends on how fast you move and on the gravitational field in which you happen to be immersed, what does it mean when astronomers and physicists speak of the entire universe's being a particular definite age—an age which these days is taken to be about 14 billion years? *Fourteen billion years according to whom? Fourteen billion years on which clock?* Would beings living in the distant Tadpole galaxy also conclude that the universe is 14 billion years old, and if so, what would have ensured that their clocks have been ticking away in synch with ours? The answer relies on symmetry—symmetry in space.[22]

Greene explains that, under the assumptions of Big Bang Cosmology, there is only one universal clock that ticks the same all over the cosmos, and in the distant past. Contra Dr. Schroeder, there is no additional "6-day cosmic clock"; there is only this one global clock.

Global time is based on clocks that are tied to the expanding space itself; in consequence, any such clock ticks the same today in our local galaxy as it did billions of years ago. That clock has

[22] Greene, Brian. The Fabric of the Cosmos (p. 226). Knopf Doubleday Publishing Group. Kindle Edition.

ticked uniformly for about 13.8 billion years (at least since the Planck time, which is much earlier than the time of quark confinement chosen by SOG[23]). Greene writes:

> Using a slight variation on the balloon model [see Figure 1], we can now understand more precisely how symmetry in space, even though space is expanding, yields a notion of time that applies uniformly across the cosmos. Imagine replacing each penny by an identical clock, as in Figure 8.3. We know from relativity that identical clocks will tick off time at different rates if they are subject to different physical influences—different motions, or different gravitational fields. But the simple yet key observation is that the complete symmetry among all Lincolns on the inflating balloon translates to complete symmetry among all the clocks. All the clocks experience identical physical conditions, so all tick at exactly the same rate and record identical amounts of elapsed time. Similarly, in an expanding universe in which there is a high degree of symmetry among all the galaxies, clocks that move along with one or another galaxy must also tick at the same rate and hence record an identical amount of elapsed time. How could it be otherwise? Each clock is on a par with every other, having experienced, on average, nearly identical physical conditions. …
>
> Recall from Chapter 3 that Einstein discovered that clocks that move through space in different ways tick off time at different rates (because they divert different amounts of their motion through time into motion through space; …). *But the clocks we are now discussing are not moving through space at all. Just as each penny is glued to one point on the balloon and only moves relative to other pennies because of the swelling of the balloon's surface, each galaxy occupies one region of space and, for the most part, only moves relative to other galaxies because of the expansion of space. And this means that, with respect to space itself, all the clocks are actually stationary, so they tick off time identically*. It is precisely these clocks—clocks whose only motion comes from the expansion of space—that provide the synchronized cosmic clocks used to measure the age of the universe.
>
> Notice, of course, that you are free to take your clock, hop aboard a rocket, and zip this way and that across space at enormous speeds, undergoing motion significantly in excess of the cosmic flow from spatial expansion. If you do this, your clock will tick at a different rate and you will find a different length of elapsed time since the bang. This is a perfectly valid point of view, but it is completely individualistic: the elapsed time measured is tied to the history of your particular whereabouts and states of motion. *When astronomers speak of the universe's age, though, they are seeking something universal—they are seeking a measure that has the same meaning everywhere.* The uniformity of change throughout space provides a way of doing that.
>
> In fact, the uniformity of the microwave background radiation provides a ready-made test of whether you actually are moving with the cosmic flow of space. You see, although the microwave radiation is homogeneous across space, if you undertake additional motion beyond that from the cosmic flow of spatial expansion, you will not observe the radiation to be homogeneous. Just as the horn on a speeding car has a higher pitch when approaching and a lower pitch when receding, if you are zipping around in a spaceship, the crests and troughs of the microwaves heading toward the front of your ship will hit at a higher frequency than those traveling toward the back of your ship. Higher-frequency microwaves translate into higher temperatures, so you'd find the radiation in the direction you are heading to be a bit warmer than the radiation reaching you from behind. As it turns out, here on "spaceship" earth, astronomers do find the microwave background to be a little warmer in one direction in space and a little colder in the opposite direction. The reason is that not only does the earth move around the sun, and the sun move around the galactic center, but the entire Milky Way galaxy has a small velocity, in excess of cosmic expansion, toward the constellation Hydra. Only when astronomers correct for the effect these relatively slight additional motions have on the microwaves we receive does the radiation exhibit the exquisite uniformity of temperature between one part of the sky and another. It is this uniformity, this overall symmetry between one location and another, that allows us to speak sensibly of time when describing the entire universe.[24]

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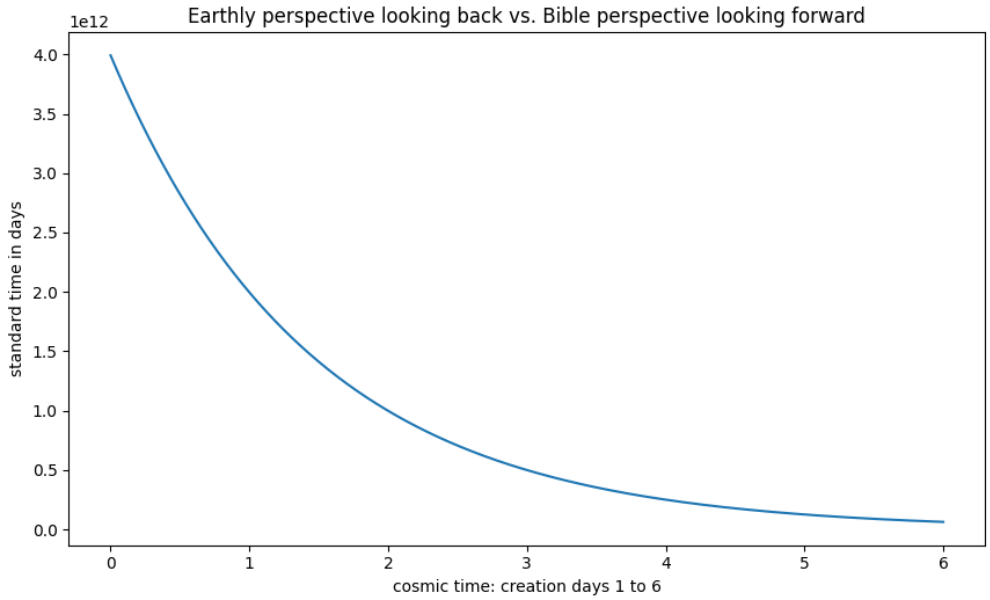
[23] It would have been reasonable for Dr. Schroeder to choose the beginning of time as we know it rather than quark confinement, but that would have undermined his calculations.

[24] Greene, Brian. The Fabric of the Cosmos (pp. 235-236). Knopf Doubleday Publishing Group. Kindle Edition.

5 An ad-hoc Formula for an ad-hoc Clock

To justify his two clock resolution (6-days and 15 billion years), Dr. Schroeder introduces an *ad hoc* exponential formula[25]: $A = A_0e^{-Lt}$. The mathematical details are shown in Figure 2 below, and are not needed to understand the critique.

Figure 2: Dr. Schroeder's putative "Cosmic Clock"



In SOG1997, page 65, Dr. Schroeder describes an exponential function A to convert a Biblical six-day "Cosmic Clock" into the standard age of the universe, where $A = A_0e^{-Lt}$ (plotted above[26]).

- A0 = 10.9 x $10^{12}/2.73 = 3.99268 \times 10^{12}$ (Degrees K at quark confinement to the current value)
- L is the natural log of 2 = 0.693.
- A is earth time, the number of current standard earth days contained within one Genesis day at any given instant during the six day period.

To learn the duration of each Genesis day as viewed from our perspective of time, we integrate the equation and solve this integrated form for each of the six days of Genesis. Integrating A, we obtain $(-A_0/L)e^{-Lt}$.
Solving the integral, Genesis day one begins 15.75 billion years ago and ends 7.75 billion years before the present.

Why do I call the mathematical resolution via a putative "cosmic clock" ad hoc? For a number of reasons.

1. Dr. Schroeder wrote that "*with the insights of Albert Einstein, we have discovered in the six days of Genesis the billions of years during which the universe developed.*" [SOG1997, page 71]. Despite this claim, his exponential formula A_0e^{-Lt} (in Figure 2) for a six-day "cosmic clock" is not found in the reputable scientific literature. As shown in Section 4, scientists have only one uniform clock that has ticked the same for about 13.8 billion years.

[25] SOG1997, pages 65 to 67.
[26] I don't quite get quite the same numbers as Dr. Schroeder, but this is of minor concern, as the order of magnitude is the same. So this will not impact on the critique.

2. Dr. Schroeder's "cosmic clock" is his own invention cherry picked to obtain the desired result of reconciliation.
3. Dr. Schroeder's mathematical development for his cosmic clock appears impressive. He refers to Bernoulli and Cartesian coordinates, superscripts, subscripts, instantaneous ratios, natural logs, and Euler's constant [SOG1997, pages 66-68.], but when he finally gets to the heart of his presentation, we find that all he is really doing to determine the age of each biblical day is simply dividing his selected age of the universe into long ages based on an invented exponential equation.
4. The exponential formula yields different earth periods for each cosmic day is not justified by his argument that earth time is simply redshifted cosmic time. While an exponential relationship would apply for the inflationary epoch in the early universe (see Section 7.2), that has ended by the time of quark confinement. Afterwards we have an almost linear Hubble expansion in which the redshift varies as a power law with time, not exponentially. Having each cosmic day about half as long as the preceding one in earth years is an unjustified procedure.
5. How did he decide to divide the universal age with this invented exponential formula? He does not say other than the need to match it with vague allusions to Genesis (time periods that had to altered when the need to have 16 billion years in 1997 changed to the current value of about 13.8 billion years). If we can invent equations, then with perhaps equal logic, why not divide the 13.8 billion years by six days and claim that each biblical day approximated 2.3 billion conventional years.
6. To make his claim work, Dr. Schroeder chose "quark confinement" as the beginning of his time scale (10^{-6} seconds after the Big Bang at 10^{13} degrees K). But there are equally valid later and earlier times that he could have chosen. But that would have introduced large discrepancies in his calculations.
    a. For example, he might have chosen as his beginning of time the Recombination Era at about 380,000 years after the Big Bang when the intense heat from the universe's creation cooled to 3000 degrees Kelvin (3 times 10^3) enough for electrons to combine with nuclei to form neutral atoms (the basic building blocks of the cosmos). This is also the time at which the light that is detectable today was unleashed and began to shine. The problem with that choice is that instead of 15.7 billion years for the age of the universe, it would only be a few thousand years old in standard time (i.e., much too young). See Section 7.2 for the temperature details.
    b. There are many earlier eras that are much more likely for a beginning of time than quark confinement. The earliest of them is the Planck time at 10^{-43} seconds when the temperature might have been an astounding 10^{32} degrees Kelvin. That would make the universe trillions and trillions of years older than its current estimate. See Section 7.2 for the details.
7. As a final point, see the Appendix 7.3.

6 The Torah View: Meta-Natural Creation

Rabbi Miller wrote as follows (December 11th, 2005):

הכונה במה שכתבתי "מהות הזמן" היינו חוקי הטבע שונים לגמרי בו' ימי בראשית ממה שאפשר להמצא עכשיו וכל מה שכתב Dr. Schroeder הוא על חוקי טבע הנוהג עכשיו וע"כ אין שום דמיון ממשכתבתי למשכתב החכם הנ"ל.

(Transcribed from the original draft by Yoel Ostroff)

The first few chapters of the Torah describe how the organized complexity of life came about. During the creation week, Hashem brought into existence *ex nihilo* (יש מאין) the universe including space, time and the very laws of nature. Subsequently, He fashioned the galaxies of stars, our solar system with the sun and the moon, and ultimately the earth as an exquisite habitat fine-tuned for life and discovery.
On the 6th day, man is created in the divine image. This ends the phase of **meta-natural** creation (בריאה) in which Hashem brings forth novel entities outside the laws of nature currently in operation.

> "On each day of the six day creation week, novel entities were formed *outside of the laws of nature currently in operation*, and on the seventh day (Shabbos) the state of the world become lasting and established just as it is at present" (Rambam, *Moreh Nevuchim*, 1:67).
> **רמב"ם מ"נ א:סז**: בכל יום מן הששה היו מתחדשים בו חידושות מחוץ לטבע הזה המצוי עתה בכללותה, ובוים השביעי התמיד הדבר ונתיצב כפי שהוא עתה.

The concept of meta-natural Creation Week permeates the Torah, *Chazal* and all the *Rishonim*. The Maharal writes as follows:

> [מהר"ל באר הגולה באר הרביעי דף פ"ג] דע כי הוא יתברך הוציא את הנמצאים כולם לפעל המציאות בששת ימי בראשית בעצמו ובכבודו, לא ע"י שליח הוא הטבע, כמו שהיה אחר ששת ימי בראשית שהש"י מנהיג את עולמו ע"י השליח והוא הטבע.
>
> Know that He, may His name be blessed, caused all of reality to materialize into existence during the six days of creation Himself, in His own Glory (*b'chvodo u'veatzmo*) and not through the agency of nature, as opposed to the period which ensues after the six days of creation in which Hashem, may His name be blessed, governs his creation via the intermediary of nature.

Shabbos is the demarcation point between *meta-natural* creation and the natural operation of the universe with G-d sustaining it, here and now, and guiding it. On the 7th day (שבת), He rested. In this era, God sustains and supervises creation (הנהגה). Shabbat commemorates the transition from בריאה to הנהגה.

> Remember the Sabbath day to sanctify it. … For in six days Hashem made the heaven and earth and all that is in it, the sea and all that is in them, and He rested on the seventh day (*Shemos* 20:8-12).

From that moment in time, the world and the laws of nature operate in an orderly and stable fashion under His supervision. The order of creation makes the world intelligible, making possible the modern scientific enterprise. Stunning new scientific information has added to our awareness that enormous intelligent agency is implicated. We are here by design.

This is one of the reasons why theistic evolution (the idea that G-d is behind evolution) contradicts fundamental principles of Torah. Existence as we know it does not come about via natural processes such as Big Bang Cosmology or Evolution.

Let's get back to Dr. Schroeder's quote of Psalm 90:

> There is a simple answer to the problem of a scientifically old and biblically young universe, an answer that has within it the core of a complex truth. Time as described in the Bible may not be the same as we know time today. We find a hint for this in the 2,900-year-old Book of Psalms: "*A thousand years in Your sight are as a day that passes, as a watch in the night*" (Ps. 90:4). Perhaps from a biblical perspective the six days of Genesis include the fifteen billion years we earthbound mortals estimate to be the span of time since the beginning of time, just as a watch in the night might include a thousand years. That makes sense…if you believe Psalm 90!

Dr. Schroeder is aware that the Ramban (and Rashi in the Talmud) explain that the word "day" in Genesis is a regular 24 hour day.:

> Know that the term "day" as used in the story of the creation was, in the case of the creation of heaven and earth, *a real day*, composed of hours and seconds, and there were six days like the six days of the workweek, as is the plain meaning of the verse. [*Ramban*, Gen. 1.3]

I do not know of any place in the Ramban where he mentions 15 billion years of evolution. What about the meaning of the Psalm that "*A thousand years in Your sight are as a day that passes, as a watch in the night*"? Here is the Ramban to Gen. 2.3:

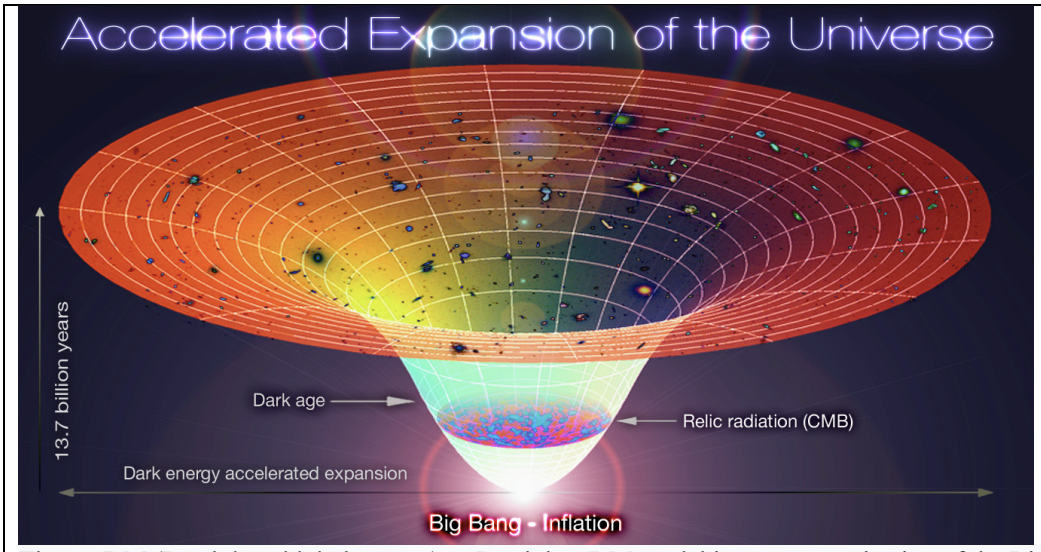
> Know that in the word *la'asoth* (to make, to do) is also included a hint that the *six days of creation represent all the days of the world*, i.e., that its existence will be six thousand years. For this reason the Rabbis have said: "*A day of the Holy One, blessed be He, is a thousand years*." Thus on the first two days the world was all water, and nothing was perfected during them. They allude to the first two thousand years when there was no one to call on the name of the Eternal. And so the Rabbis said: "The first two thousand years there was desolation." *However, there was the creation of light on the first day corresponding to the thousand years of Adam* who was the light of the world and who recognized his Creator. Perhaps Enosh did not worship idols until the death of the first man. On the second day G-d said, *'Let there be a firmament… and let it divide,'* for on that "day" [i.e., the second thousand-year period] Noah and his sons — the righteous ones — were separated from the wicked, who were punished in water. On the third day, …

The Ramban understands the verse as do Chazal in Sanhedrin 97a. Each "*day*" of the six days of creation represent a *thousand* years of history which will last for 6000 years. There is no sense in which this verse in Psalms refers to 15 billion years of unguided evolution.

7 Appendix

7.1 Informal introduction to Big Bang Cosmology

Figure 3: Big Bang Cosmology via unguided natural processes



The ΛCDM (Lambda cold dark matter) or Lambda-CDM model is a parameterization of the Big Bang cosmological model in which the universe contains three major components: first, a cosmological constant denoted by Lambda (Greek Λ) associated with dark energy; second, the postulated cold dark matter (abbreviated CDM); and third, ordinary matter. It is frequently referred to as the standard model of Big Bang cosmology because it is the simplest model that describes the origin of the universe. The time-line in this schematic diagram extends from the Big Bang/inflation era about 13.8 Billion Years ago, to the present cosmological time. (Image from *Wikipedia*)

Big Bang Cosmology is a scientific theory that describes the origin and evolution of the universe via unguided natural processes. This is an example of the *origin sciences* that do not have the reliability of the *operational sciences* (which describe how the universe operate). According to Big Bang Cosmology, the universe began as a singularity—a point of infinite density and temperature—around 13.8 billion years ago. At this moment, space, time, and all matter and energy were compressed into an extremely hot and dense state.

The expansion of the universe (i.e. of space itself), known as the Big Bang, started from this singularity. In the first fraction of a second, the universe underwent a rapid phase of exponential expansion of space called cosmic inflation. This inflationary period smoothed out irregularities and set the stage for the subsequent formation of galaxies and other cosmic structures.

As the universe expanded, it also cooled down. Around 380,000 years after the Big Bang, the temperature dropped enough for protons and electrons to combine, forming neutral atoms. This event, known as recombination, allowed photons to travel freely through space, creating the cosmic microwave background radiation, which we detect today as a faint glow in the universe.

7.2 First 3 minutes of Big Bang Cosmology

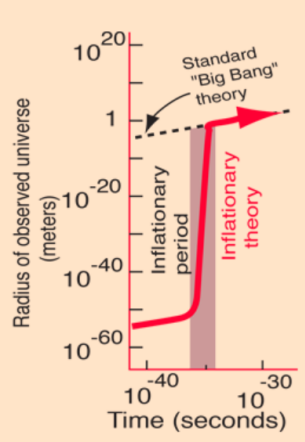
The following information is taken from:

- Steven Weinberg, winner of the 1979 Nobel prize in physics: *The First Three Minutes*, Basic Books, New York, 1977. Updated version 1993 with an afterword by the author. This author and book are often referred to in SOG.
- James Trefil, *The Moment of Creation, Big Bang Physics from before the first milliseconds to the Present Universe*, Collier Books, 1983.
- Other sources referenced in the footnotes. 1 GeV is a thermal energy of about 1.16045 times 10^{13} degrees Kelvin. [27]

0 seconds: This is before the Planck time. Here lie dragons! Nothing definite is known of this period. Speculation that all of the four fundamental forces are presumed to have been unified into one force. All matter, energy, space and time are presumed to have exploded outward from the original singularity.

10^{-43} seconds: Planck time. In the era around one Planck time, present modeling of the fundamental forces is that the force of gravity begins to differentiate from the other three forces. The temperature at this time is assumed to be $1.42*10^{32}$ degrees Kelvin!

10^{-36} seconds: Beginning of the quark era. The strong force separates out from the electroweak force (electromagnetism and the weak force are still unified). In the 1970's, Sheldon Glashow and Howard Georgi described the grand unification of the strong, weak, and electromagnetic forces at energies above 10^{14} GeV (at a temperature of 10^{27} degrees Kelvin for the thermal energy). Though the strong force is distinct from gravity and the electroweak force in this era, the energy level is still too high for the strong force to hold protons and neutrons together, so that the universe is still a "sizzling sea of quarks".



[27] For the numbers below are from The First Three Minutes (Weinberg), The Moment of Creation (Trefil), and http://hyperphysics.phy-astr.gsu.edu/hbase/Astro/planck.html and https://www.space.com/13320-big-bang-universe-10-steps-explainer.html and https://www.e-education.psu.edu/astro801/content/l10_p8.html.

10^{-32} seconds: End of inflationary era. From the beginning of the quark era until 10^{-32} seconds, it is proposed that there was an extraordinary inflationary phase. More expansion of space is presumed to have occurred in this instant than in the entire 13.7 billion years of the cosmos.

10^{-6} seconds: Quark confinement era. When the expansion of the "primordial fireball: had cooled to about 10^{13} Kelvin, the collision energies had dropped to about 1 GeV and quarks could finally combine with each other to form individual protons and neutrons (the nucleus of the atom).

About 3 minutes: Hydrogen atoms and Helium nuclei form at a temperature of 10^{9} Kelvin. Helium about 26% by mass in the universe from this time on.

380,000 years: Recombination era. For the first 380,000 years after the Big Bang, the intense heat from the universe's creation made it essentially too hot for light to shine. Atoms crashed together with enough force to break up into a dense, opaque plasma of protons, neutrons and electrons that scattered light like fog. It was only after this period that the universe cooled enough for light to shine. So, at this time matter cooled enough for electrons to combine with nuclei to form neutral atoms. The light that was unleashed at this time is detectable today in the form of radiation from the cosmic microwave background. The temperature is about 3000 degrees Kelvin (3 times 10^{3})

7.3 Science of G-d, 1997 vs. 2005

The chart below is from the 1997 printing of SOG when the universe was thought to be nearly 16 billion years old. In the *Aish Hatorah* article (2005 or later) the chart had to be revised as the age of the universe is now thought to be about 13.8 billion years old. Who know what the future holds. This is not a sound basis for the analysis of the Biblical text. For that we must rely on our *baalei mesorah*.

The Six Days of Genesis

Day number	Start of day (years B.P.)	End of day (years B.P.)	Main event(s) of the day	
			Bible's description	*Scientific description*
One	15,750,000,000	7,750,000,000	The creation of the universe; light separates from dark (Gen. 1:1–5)	The big bang marks the creation of the universe; light literally breaks free as electrons bond to atomic nuclei; galaxies start to form
Two	7,750,000,000	3,750,000,000	The heavenly firmament forms (Gen. 1:6–8)	Disk of Milky Way forms; Sun, a main sequence star, forms
Three	3,750,000,000	1,750,000,000	Oceans and dry land appear; the first life, plants, appear (Gen. 1: 9–13); kabalah states this marked only the start of plant life, which then developed during the following days	The earth has cooled and liquid water appears 3.8 billion years ago followed almost immediately by the first forms of life: bacteria and photosynthetic algae
Four	1,750,000,000	750,000,000	Sun, Moon, and stars become visible in heavens (Talmud Hagigah 12a) (Gen. 1: 14–19)	Earth's atmosphere becomes transparent; photosynthesis produces oxygen-rich atmosphere
Five	750,000,000	250,000,000	First animal life swarms abundantly in waters; followed by reptiles and winged animals (Gen. 1: 20–23)	First multicellular animals; waters swarm with animal life having the basic body plans of all future animals; winged insects appear
Six	250,000,000	approx. 6,000	Land animals; mammals; humankind (Gen. 1:24–31)	Massive extinction destroys over 90% of life. Land is repopulated: hominids and then humans

Page 67, SOG. Dr. Schroeder started by discussing Einstein and his concept of time and the relativity of time between two systems. Then he abandons Einstein and relativity based on gravity or velocity for a cosmic clock with an *ad hoc* formula. For the start of day 1, he needs to measure the extent of the change of the CBR [which has little to do with the global scientific time]. But, to do so, he needs to pick a start time. The time he picks is called "quark confinement," that time within the first second after the Big Bang when subatomic particles, called quarks, joined together to form the first protons and neutrons [SOG, pages 58, 187]. What is the scientific basis for picking quark confinement? Here he switches from science to the Ramban who, according to Dr. Schroeder, teaches that Biblical time "starts ('grabs hold,' in his words) with the appearance of matter" [SOG, page 58]. Of course, even assuming that Ramban would have equated the start of matter with the speculative theory of quark confinement, this is not a rigorous application of scientific principles and methodology. Dr. Schroeder might have more reasonably picked the time when those elementary particles, such as quarks were formed, not when they were confined, and if not that, to the "Big Bang" itself and the Planck time 10^{-43} seconds after the beginning of the universe. This is a time, much before quark confinement, but that would undermine Dr. Schroeder's calculations. Much could be said for each of the subsequent days, but it suffices to leave matters there.