HAVE THE ELEMENTS EVOLVED BY STELLAR NUCLEOSYNTHESIS?

I. WHAT IS NUCLEOSYNTHESIS?

In a chemical reaction, reactant atoms rearrange themselves to form new chemical products. The reactants change into products, but the atoms themselves stay the same. We say that in a chemical reaction, the atoms are "conserved."

In a nuclear reaction atoms themselves are changed into different atoms. For an example, when atoms of the element uranium decay radioactively into other smaller atoms, the uranium atoms are gone and different atoms appear. In a nuclear reaction, the atoms are not conserved. The new atoms result from rearrangements of sub-atomic particles -- protons and neutrons -- in the nuclei of the original atoms. In a nuclear reaction, sub-atomic particles are conserved. A nuclear reaction does not create new matter any more than a chemical reaction does.

"Nucleosynthesis" is the production of atoms of an element from atoms of a different kind. Every nucleosynthesis is a nuclear reaction. In other words, a nuclear reaction involves the nucleosynthesis of atoms not existing before. In nuclear reactions and in nucleosynthesis, sub-atomic particles such as protons and neutrons are conserved, but atoms are not.

Radioactive decay is a kind of nucleosynthesis. So is the production of heavier atoms from smaller ones in particle accelerators, sometimes called "atom smashers." A particle accelerator functions by using a target made of a certain type of atom. Small particles such as neutrons are accelerated to exceedingly high speeds and act as "particle bullets" bombarding the target. Some target atoms absorb a "bullet" and become heavier, different, atoms. This is how elements with atomic numbers above those occurring in nature have been produced. Uranium with atomic number 92 has the highest atomic number of the natural elements. However, nucleosynthesis in particle accelerators has resulted in elements with atomic numbers higher than 110.

II. STELLAR NUCLEOSYNTHESIS AND THE BIG BANG ARE RELATED.

Nucleosynthesis in stars is called "stellar nucleosynthesis." The question we now consider is whether stellar nucleosynthesis could have produced the elements in nature up through uranium, element 92.

Years ago, Christians seeking to harmonize evolution with the Bible accepted biological evolution as a matter of course. Many still do, but increasingly there is a tendency to reject biological evolution as flawed, yet to insist that solar, stellar, or cosmic evolution is well grounded in scientific fact. All of these start with the presupposition of a Big Bang, a universal explosion some 13 billion years ago, followed by stellar nucleosynthesis. **Nucleosynthesis theory (NST) postulates progressive build-up of all elements ultimately from primordial hydrogen, a concept negating the biblical teaching that God made a finished creation (Gen. 2:1).**

Other than fusion of hydrogen into deuterium (an isotope of hydrogen), scarcely any of the presumed nucleosynthesis reactions have been observed. Thus if the Big Bang had really happened, we should not be here because the entire universe would be only hydrogen and deuterium. With virtually all post-Big Bang nucleosynthesis in question, it is fitting to question the Big Bang as well, since it is perceived as merely the precursor to further nucleosynthesis which in fact never occurred.

When modern Big Bang theory was first devised in the 1940s, theorists believed that nucleosynthesis in the extreme conditions of the Big Bang could account for all natural elements. Theorists soon realized this could not be. Hydrogen atoms first produced in the Big Bang would need to take on additional protons and neutrons to become helium. The helium in turn would have to take on more protons and neutrons to become lithium, and so on.

However, theorists realized that there was no way to add protons or neutrons one at a time to hydrogen atoms to obtain atoms heavier than boron (element number 5). The reason is that there are no stable isotopes with mass numbers of five and eight. Thus an atom with a mass number of 4, when taking on one more neutron, would have a mass number of 5, would be unstable, and would quickly decay. Nucleosynthesis would stop.[1] **This lack of stable isotopes of mass numbers five and eight is excellent evidence that the elements could not have been produced naturalistically and must have resulted from special creation.**

Realizing that the Big Bang could not have produced elements heavier than boron, theorists began looking to the interior of stars as likely places for nucleosynthesis of heavier elements. Stellar interiors, they believed, would be like "pressure-cookers" for nucleosynthesis, forcing smaller atoms to fuse into bigger ones under the high-pressure and high-temperature conditions presumed to exist in the centers of stars. Under such "pressure-cooker" conditions, it was thought, atoms could enter extremely hot and fast-moving "excited" states. The "excited" atoms would then easily enter into the needed nucleosynthesis reactions.

III. NST FAILS TO EXPLAIN NUCLEOSYNTHESIS IN STARS.

The element right after boron is carbon, element number 6. Carbon could not have been produced in the Big Bang. Instead, **carbon is supposed to have been produced in stars by the so-called "triple-alpha" process** to be discussed later, **then processed further by the "CNO reaction sequence"** to produce nitrogen and oxygen.

The CNO reaction sequence is a key series of nuclear reactions because it is supposedly the gateway to nucleosynthesis of all the 84 natural elements above oxygen.

It involves carbon, nitrogen, and oxygen (the CNO elements), and is believed to have led to production of elements heavier than boron in stellar interiors over billions of years. **If it does not occur, then nucleosynthesis of most elements is not possible.**

Stars were first thought of as sites for nucleosynthesis in 1939, when Hans Bethe made a proposal of nucleosynthesis by solar fusion. Bethe believed that the CNO reactions provided most solar energy.[2] Today this is known not to be true; most solar energy comes from hydrogen fusion. Further, all theorists acknowledge that CNO reactions in the sun lead to virtually no nucleosynthesis of atoms heavier than helium.[3]

Following Bethe's idea of CNO reactions in the sun and presumably other stars, theorists found themselves unable to work out how the sun could support the CNO reactions. By this time, the Big Bang had been ruled out as a possible way to build carbon and heavier elements by nucleosynthesis from smaller atoms. There was no way to force boron to grow into heavier atoms even at the high-pressure conditions in stellar interiors.

IV. FRED HOYLE AND HIS CARBON-12 "RESONANCE" RESCUED NST -- OR DID THEY?

In 1953 astrophysicist Fred Hoyle, working with William Fowler, successfully predicted a certain state of ^{12}C called a "resonance." (Remember that a superscript on a chemical symbol such as ^{12}C indicates the mass number of the isotope.) **An atom in a resonance state is liable to react, though the same atom ordinarily would not undergo reaction.**

You have probably encountered the principle of resonance when pushing a friend on a swing. If you push him at the proper frequency, it is easy with each push to make the swing go higher and higher until finally your friend may "react" by falling off, or having to jump off, the swing. Like your friend on the swing, **an atom in resonance can continue to absorb energy until it finally reacts.**

Hoyle's predicted resonance state for ^{12}C in the CNO sequence would supposedly allow atoms of ^{12}C to form and react, allowing the CNO sequence to occur under solar conditions.[4] As already mentioned, the CNO sequence was later recognized as less and less likely to occur in the interior of the sun or any normal star.[5] Fowler et al.[6] then proposed that C, N, and O reactions happen on the surfaces of stars due to local heating by magnetic fields. After this, the CNO reactions were ruled out as significant in solar-type stars.[7] C, N, and O reactions have been postulated for very hot, massive stars,[8] or supernovae.[9] **Evidence (as opposed to theory) fails to confirm that the CNO sequence occurs significantly anywhere.**

The story of Hoyle's successful prediction has been told and re-told as if it confirms the CNO sequence, and therefore NST in general. It is the kind of story that is presented in graduate classes as support for NST, with the implicit claim that nucleosynthesis of ^{12}C has been observed. But this is not true; **^{12}C synthesis has never been observed, rendering the CNO sequence devoid of ^{12}C input.**

V. THE CNO SEQUENCE IS AN UNOBSERVED THEORETICAL CONSTRUCT.

Aside from theoretical speculation, little is actually known about the CNO sequence. Reaction rates for C, N, and O reactions are some of the most uncertain quantities in stellar NST.[10] This has long been acknowledged.[11] A team of scientists, the LUNA Collaboration, recently revised the rate for onset of CNO burning down by about 50 percent, thus changing the estimated ages of globular clusters by about 1 billion years,[12] and decreasing more the potential significance of CNO reactions in the sun and other stars.

Yet as mentioned above, occurrence of CNO reactions is believed to be essential for stellar nucleosynthesis of elements above boron (B).[13] CNO burning "is central to the idea that the heavy elements are formed by nuclear processing in stars during their late stages of evolution."[14] It has been invoked theoretically to drive helium (He) synthesis[15] in He stars[16] or novae[17] as well as white dwarfs and neutron stars.[18] In short, **the CNO sequence is extremely important in NST, and the stakes are high to confirm that it happens.**

In the sun most excited boron ($^{8}B^{*}$) decays into two alpha (α) particles (He nuclei with mass number of 4) at presumed solar core conditions, so as mentioned above, the CNO sequence is unimportant in the sun. However, the reaction

$$^{8}B^{*} + \alpha \rightarrow {}^{12}C$$

would hypothetically provide ^{12}C to feed into the CNO sequence.[19] This is supposed to be a rare reaction in the sun and sun-like stars. According to NST, conditions in certain other hotter stars allow a more efficient reaction to form ^{12}C, the so-called **"triple alpha" (3α) process.** This is "the collision of three α-particles"[20] to form ^{12}C via Hoyle's ^{12}C resonance:[21]

$$\alpha + \alpha + \alpha \rightarrow {}^{12}C$$

The ^{12}C thus synthesized feeds into CNO reactions. Fowler, Cook et al., and Salpeter[22] reported what has been characterized as "experimental discovery" of the ^{12}C resonance Hoyle predicted.[23] This claim has led to the belief that the CNO sequence is based on observation. This belief needs correcting. **Despite Hoyle's successful prediction, solar/stellar NST has not answered basic questions about how the elements originated:**

"In spite of the past and current research in experimental and theoretical nuclear astrophysics ... Hoyle's grand concept of element synthesis in stars [is not] truly established. ...It is not just a matter of filling in the details. There are puzzles and problems in each part of the cycle which challenge the basic ideas underlying nucleosynthesis in stars."[24]

VI. ONLY THE DECAY OF ^{12}C HAS BEEN OBSERVED, NOT NUCLEOSYNTHESIS OF ^{12}C.

Hoyle was correct in his prediction of the ^{12}C resonance, but contrary to popular belief, this does not help NST. Indeed, ^{12}C synthesis with Hoyle's predicted resonance has not been observed. **The actual "experimental discovery" was of ^{12}B decaying to an excited ^{12}C state ($^{12}C^*$), followed by decay to three α particles.[25]** Thus *decay* into 3 α was observed, not the reverse reaction of 3 α forming ^{12}C. Fowler claims that "by reciprocity [^{12}C] could be formed from 3α,"[26] but the required three-body process is problematic.[27] In fact, the inverses (i.e., reverse reactions) of three-body decays "cannot be observed, because three particles must be brought together."[28]

Thus formation of 3 α by decay is irrelevant to theoretical ^{12}C synthesis, and the process leading to ^{12}C remains unobserved. Confusing decay processes with putative synthesis is endemic in conventional astronomy.[29] It could be objected that reciprocity guarantees occurrence of the 3α process, but in fact the very mechanism of ^{12}C synthesis is disputed.[30] There may not be a 3α interaction: "Despite the long history of investigations it is yet unclear to what extent the three-body picture accounts for the real [process]. . ."[31]

Failure to observe nucleosynthesis of ^{12}C has a significance that cannot be over estimated. **The key CNO reaction sequence in stellar NST is only a theoretical construct. One believes it by faith, not by observation.** Additional examination reveals that in the sun[32] and in the laboratory, most other reactions of stellar NST are also unobserved, leaving virtually all of stellar NST a theoretical construct. Lack of stellar nucleosynthesis leaves the Big Bang as a precedent without a conclusion. **With virtually all NST being imaginary, it would appear reasonable to view the Big Bang as imaginary, too.**

VII. CONCLUSIONS

Even if the Big Bang had happened, it could not have produced any elements beyond boron. Stellar nucleosynthesis of elements beyond boron requires (1) the triple alpha (3α) process to produce ^{12}C; and (2) occurrence of the CNO sequence to synthesize C, N, and O, thus allowing nucleosynthesis of higher elements.

But the 3α process has not been observed. Only decay of boron, ^{12}B into an excited state of carbon ($^{12}C^*$), then into three alpha particles, has been observed. Granting that the 3α process occurs -- a supposition unsupportable by observations -- reaction rates for the CNO sequence are poorly known. It is certain that the CNO sequence is insignificant in the sun and sun-like stars. No observational evidence has been found to support the claim that it is significant in non-solar-type stars.

With the 3α process unobserved and the CNO process only hypothetical, virtually all of NST must be relegated to the realm of speculation, since the CNO reactions are the key for presumed nucleosynthesis beyond boron. Lack of nucleosynthesis via NST leaves the Big Bang and its presumed, but limited, nucleosynthesis open to question as well. Further, lack of evidence for nucleosynthesis above deuterium reinforces the biblical claim that in the beginning, **God over six days spoke a finished creation into existence (Gen. 2:1), complete with the elements we now find in nature.**

In NST, we have a system of thought so complex that the average person cannot understand it and is willing to allow humanists to continue their evolutionary claims. In other words, layer upon layer of theory has been laid down to support the claim that the universe was not created but evolved. To explain the evolution of the elements, there was first the Big Bang, followed by (2) stellar nucleosynthesis including the CNO sequence, then (3) the CNO sequence backed up by the 3α process which is still hypothetical.

Adding layer on layer to theories designed to displace God from origins -- as the theories become ever more complex -- is what the Bible means when it says that in the end times "evil men ... shall wax worse and worse, deceiving and being deceived" (2 Tim. 3:13). Note that the Bible does not claim that all things will wax worse and worse. That is why technology is improving. The earth's ecological state, contrary to common belief, is also getting better, as are human life expectancy and medical science.[33] Nevertheless, **evolutionary theory is waxing worse and worse because, in refusing to acknowledge its failures, it has added layer upon layer of theoretical resistance to the biblical claim that God created.**

Notes

1 Fowler, W., "The Quest for the Origin of the Elements," *Science*, Vol. 226, 1984, p. 922.

2 Bahcall, J., M. Gonzales-Garcia, and C. Pena-Garay, "If Sterile Neutrinos Exist, How Can One Determine the Total Solar Neutrino Fluxes?," *Physical Review C*, Vol. 66 article no. 035802, 2002, p. 1.

3 The CNO sequence commonly theorized for the sun has two parts:

$$H + {}^{12}C \rightarrow {}^{13}N + \gamma$$
$${}^{13}N \rightarrow {}^{13}C + e^+ + \nu_e$$
$$H + {}^{13}C \rightarrow {}^{14}N + \gamma$$
$$H + {}^{14}N \rightarrow {}^{15}O + \gamma$$
$${}^{15}O \rightarrow {}^{15}N + e^+ + \nu_e$$
$$H + {}^{15}N \rightarrow {}^{12}C + {}^4He$$

and

$$H + {}^{15}N \rightarrow {}^{16}O + \gamma$$
$$H + {}^{16}O \rightarrow {}^{17}F + \gamma$$
$${}^{17}F \rightarrow {}^{17}O + e^+ + \nu_e$$
$$H + {}^{17}O \rightarrow {}^{14}N + {}^4He$$

In these reactions, γ is gamma radiation which is emitted at the sun's surface as light and heat; ν_e is an electron neutrino, a type of particle much smaller than an electron believed to be produced in certain nuclear reactions.

In the first part, solar hydrogen reacts with carbon produced by the "triple-alpha" process (discussed later in the text) from boron. In the second part, solar hydrogen reacts with nitrogen formed in the first part of the CNO sequence. In both parts, the only net product is helium produced in the final reaction of each part. In hotter stars believed to have less hydrogen, the final reaction of each part would not be so likely and further nucleosynthesis is theorized beyond the C, N and O produced in the CNOsequence.

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10 Wallerstein et al., op. cit., p. 999; Salpeter, 1999, op. cit., p. S220.

11 Khairozzaman, A., "Screened Triple-Alpha Reaction Rate to Produce Carbon in Stellar Interiors," *Astrophysics and Space Science*, Vol. 95, 1983, p. 179.

12 LUNA Collaboration, "The Bottleneck of CNO Burning and the Age of Globular Clusters," *Astronomy and Astrophysics*, Vol. 420, 2004, pp. 625, 626.

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14 Fushiki, I., and D. Lamb, "*S*-Matrix Calculation of the Triple-Alpha Reaction," *Astrophysical Journal*, Vol. 317, 1987, p. 368.

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