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Immortality is Conditional: Annihilation in Hell

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Abstract
In the Bible, the nature of how individuals are punished in Hell has been long debated. In this paper, taking the Annihilationist viewpoint of the body and soul being completely destroyed in the fires of Hell, an estimate of the energy required to do so will be estimated. By considering the binding energies of atomic nuclei, and the nucleons themselves, a value of 6.27 exajoules was calculated in the case of a 70 kg human, comparable to the yearly energy consumption of the UK.

Keywords: *Scripture; Physics; Binding Energy; Hell*

Introduction
In the New Testament, Matthew 10:28 [1] speaks of "the One who is able to destroy both soul and body in hell." This has caused debate in Christian circles about the nature of Hell, and whether those to be punished are to endure eternal punishment or to be totally annihilated after being damned to Hell [2].

This paper aims to discuss the final, the Annihilationist viewpoint, empirically. The existence of the human soul has yet to be experimentally proven, and discussions of this matter are out of the scope of this paper. However, using the assumption that the soul is an emergent corporeal phenomenon, the same conditions required to destroy the body will in turn destroy the soul. Therefore, the energy required to disperse all particles of the human body at each level of complexity can be calculated for an order of magnitude estimate of Biblical annihilation. Here, annihilation is defined as the complete dissociation the human body into unconfined quarks and gluons, elementary particles that are unable to be divided further. The first step is the dissociation the bonds of each molecule in the body into their constituent atoms, followed by the full ionisation of each atom, leaving only the nucleus. Next, the nucleus is to be split into separate nucleons, followed by the theoretical breaking apart of said nucleons into elementary particles.

Human Body Composition
The human body is a complex mix of tissues, visceral organs, bone, muscle and adipose tissue which are comprised of proteins, lipids and water. The human body contains up to 75% water by mass [3], as well as containing examples of extremely large proteins, such as titin, which possesses a molecular weight of over 3×10^6 Da [4]. However, the energy required to dissociate bonds into atoms is negligible, 0.01 eV in water [5], as is the energy required for ionisation. In comparison, the binding energy required for an oxygen atom is 7.97 MeV per nucleon [6]. Therefore, this model will assume the human body to be a collection of its constituent atoms rather than molecules.

Six elements account for 99% of the mass of the human body [7] – oxygen, carbon, hydrogen, nitrogen, calcium and phosphorus, and Table 1 shows the main elements of the human body that will be used to calculate nuclear and nucleon binding energies. Equation 1 allows for the calculation of the number of atoms of each element given the mass of each element:

$$N = \frac{m}{M_w} N_A \quad (1)$$

where N is the number of atoms, m is the mass fraction (kg), $M_w$is the atomic weight (kg/mol) and N_A is Avogadro's number, respectively.

Binding Energy

Nuclear binding energy represents the energy required to disassemble a nucleus into unbound protons and neutrons. Table 1 shows the amount of energy required to free the total number of nucleons within each atom of the human body, giving a total nuclear binding energy of 2.99×10^{35} eV.

Element	Percent by mass	Total mass (kg)	No. atoms	Nucleons per atom	Total no. nucleons	Binding energy per nucleon (eV)	Total nuclear binding energy (eV)
Oxygen	65%	45.5	1.71×10^{27}	16	2.74×10^{28}	7.98×10^{6}	2.19×10^{35}
Carbon	18%	12.6	6.32×10^{26}	12	7.59×10^{27}	7.68×10^{6}	5.83×10^{34}
Hydrogen	10%	7	4.22×10^{27}	1	4.22×10^{27}	N/A	N/A
Nitrogen	3%	2.1	9.03×10^{25}	14	1.26×10^{27}	7.48×10^{6}	9.46×10^{33}
Calcium	1.5%	1.05	1.58×10^{25}	40	6.32×10^{26}	8.55×10^{6}	5.41×10^{33}
Phosphorus	1.2%	0.84	1.63×10^{25}	31	5.06×10^{26}	8.48×10^{6}	4.29×10^{33}
Potassium	0.2%	0.14	2.16×10^{24}	39	8.43×10^{25}	8.56×10^{6}	7.22×10^{32}
Silicon	0.2%	0.14	2.63×10^{24}	32	8.43×10^{25}	8.48×10^{6}	7.15×10^{32}
Chlorine	0.2%	0.14	2.41×10^{24}	35	8.43×10^{25}	8.52×10^{6}	7.18×10^{32}
Sodium	0.1%	0.07	1.83×10^{24}	23	4.22×10^{25}	8.11×10^{6}	3.42×10^{32}
Magnesium	0.05%	0.035	8.78×10^{23}	24	2.11×10^{25}	8.26×10^{6}	1.74×10^{32}

Table 1 – Elements of the human body by percentage mass. Assuming a human weighing 70 kg, the total number of atoms of each element can be estimated, followed by the binding energy of each nucleon in each atom. Values are taken from [6-8].

Protons and neutrons are made up of a combination of three quarks, and are held together by the strong nuclear force. No isolated quark has been observed, as the amount of potential energy diverges as they are separated. However, the temperatures of the early universe were great enough to form a quark-gluon plasma, effectively decoupling the quarks from each other [9].

Total no. protons	Total no. neutrons	Total energy (eV)
2.31×10^{28}	1.89×10^{28}	3.89×10^{37}

Table 2 – The total number of nucleons in the human body, calculated using the data from Table 1 and the total energy required for decoupling.

The binding energies of protons and neutrons are 928.9 MeV and 927.7 MeV respectively [6], giving an estimate of 3.89×10^{37} eV to annihilate all hadrons in the human body. The total energy required to overcome the strong nuclear force at both levels is 3.92×10^{37} eV, which converts to 6.27 exajoules.

Conclusion

A value of 6.27 exajoules to completely destroy body and soul is of a similar order of magnitude to the annual energy consumption of the UK [10]. This would require conditions only seen a millionth of a second after the Big Bang, where temperatures were of the order of 10^{12} Kelvin [9], and the assumption that Hell is of a similar temperature can be made.

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