# Journal of Interdisciplinary Science Topics

## Nuclear Potential of the Human Race

Connor Thomas
*The Centre for Interdisciplinary Science, University of Leicester*
28/03/2017

**Abstract**
The human body contains many elements and isotopes, some of which people may not realise can be found in the human body, such as uranium. Uranium has been used to create useful electrical energy and nuclear bombs, and this paper investigates the use of the human population as a source of the uranium and plutonium needed to create nuclear bombs. It was found that the average human contained $0.63\ \mu\text{g}$ of U-235, and concluded that whilst no bomb could be created using U-235, it would be possible to create 107 Pu-239 bombs using the U-238 found in the entire human race with a population of $7.43 \times 10^9$.

**Introduction**
Many people know that human body is primarily composed of oxygen, carbon, hydrogen, nitrogen and calcium [1], but it also contains radioactive isotopes. This has led to the development of techniques such as radiocarbon dating, which utilises carbon-14 to determine the approximate age of organic matter.

Other radioactive elements are also present in the human body such as uranium. Uranium enters the human body through ingesting foods which are grown in soils containing trace amounts of uranium [2]. The average amount in the body is not harmful, and would only impact the kidneys chemically if present in high concentrations [2].

Only two nuclear bombs have been detonated as weapons, but many more have been detonated in tests. These bombs release massive amounts of energy, and the human body contains a small amount of the high energy yielding resource used in the bombs [1]. It is therefore theoretically possible for humans to become a source of uranium, although the extraction technique is not investigated in this paper.

**Theory and discussion**
Uranium naturally exists as nine isotopes, though only three of these are relatively abundant. These isotopes are U-238, U-235, and U-234 which have abundances of approximately $99.3\%$, $0.7\%$, and $0.005\%$ respectively [3]. Out of these three elements, it is U-235 which is used for both energy and weapon purposes. In both cases, the U-235 is enriched (separated from U-238) so that the uranium used has more of the fissionable U-235 present.

Fission is the process in which an element splits apart, releasing huge amounts of energy. Other products of fission are lighter elements and neutrons. Fission can occur spontaneously in heavy elements, or can be induced by the capture of thermal neutrons; neutrons with energies of roughly 0.025 eV [4]. Because neutrons are a product of fission, these can induce the fission of neighbouring nuclei to cause a chain reaction. This is the concept exploited to create nuclear bombs, in which the contained U-235 can follow this typical fission reaction [5]:

$$\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{141}_{56}\mathrm{Ba} + {}^{89}_{36}\mathrm{Kr} + 3\mathrm{n} \qquad (1)$$

This shows a U-235 atom capturing a thermal neutron to create the lighter elements barium-141 and krypton-89 as well as three more thermal neutrons.

The first nuclear bomb used in warfare was Little Boy, which was dropped on Hiroshima, Japan in 1945. This bomb contained 64 kg of enriched uranium [6] which gave an explosive yield equivalent to $15\ \mathrm{kt}$ of TNT [6].

As the average human body usually contains $90\ \mu\text{g}$ of uranium [1], it is a possible source for the creation of nuclear bombs. Due to the isotopic abundances, only around $0.63\ \mu\text{g}$ of U-235 ($0.7\%$ of the $90\ \mu\text{g}$ of uranium) will be present in the average human body.

By calculating the ratio of the mass of uranium needed to create another Little Boy to the mass of uranium per human, the number of people who would be required is determined to be $1.02 \times 10^{11}$ humans:

$$\frac{64\ \mathrm{kg}}{6.30 \times 10^{-10}\ \mathrm{kg\ humans^{-1}}} = 1.02 \times 10^{11}\ \mathrm{humans} \quad (2)$$

This is much larger than the current human population of the Earth, which was estimated at $7.43 \times 10^{9}$ as of 2016 [8].

From the human population of Earth and the average amount of U-235 inside a human body, it is calculated that there is a total of 4.66 kg present on Earth in the body of humans. This is not even enough to create the smallest nuclear bomb (core and casing), the Davy Crockett, which had a warhead weighing 23 kg [9].

Of course, it is not only U-235 which has been used in nuclear bombs. The second and last nuclear weapon detonated in an offensive attack was Fat Man which utilised plutonium-239. This is created in nuclear reactors from U-238 following this reaction [10]:

$$^{238}_{92}\mathrm{U} + \mathrm{n} \rightarrow {}^{239}_{92}\mathrm{U} \xrightarrow{\beta^-} {}^{239}_{93}\mathrm{Np} \xrightarrow{\beta^-} {}^{239}_{94}\mathrm{Pu} \qquad (3)$$

This shows a U-238 atom capturing a thermal neutron to create U-239, which undergoes beta decay to produce neptunian-239, which then also undergoes beta decay to produce plutonium-239.

The potential mass of Pu-239 obtainable from the human body is $89.37\ \mu\mathrm{g}$ ($99.3\%$ of the $90\ \mu\mathrm{g}$ of uranium), assuming there is a $100\%$ efficiency in converting the U-238 to Pu-239. The total amount of U-238 which can be converted into Pu-239 in the whole human population is therefore $664.26\ \mathrm{kg}$; much higher than the amount of U-235 present in the human race. Fat Man's core contained $6.2\ \mathrm{kg}$ of Pu-239 [4] and so it is theoretically possible to create 107 nuclear bombs, based solely on the Pu-239 created from the U-238 content of humans.

**Conclusions**

Nuclear bombs have been stockpiled since their initial creation during World War II. The source of the fissionable material used is found in the rocks of the Earth. There is however, small amounts of both U-235 and U-238 present in the human body. U-235 was used in the first and smallest nuclear bomb to be used in warfare, and had a core mass of 64 kg. There is only 4.66 kg of U-235 present in the entire human populace, which is not enough to create a nuclear bomb. From the U-238 found in humans, there is however, the potential to create 664.26 kg of Pu-239 for use in a plutonium based nuclear bomb. This would allow for 107 nuclear bombs to be produced from the human race, based solely on creating Pu-239 from the U-238 contained in humans.

**References**

[1] Forbes, G.B. (1987) *Human Body Composition. 1st ed*. New York: Springer-Verlag New York. pp 170

[2] Agency for Toxic Substances and Disease Rigistry, 2015. *Toxic Substance Portal - Uranium.* [Online] Available at: https://www.atsdr.cdc.gov/phs/phs.asp?id=438&tid=77 [Accessed 14 March 2017]

[3] Emsley, J. (2011) *Nature's Building Block: An A-Z Guide to the Elements. 2nd ed*. New York: Oxford University Press Inc. pp 601

[4] Encyclopædia Britannica (1998) *Thermal neutron.* [Online] Available at: https://www.britannica.com/science/thermal-neutron [Accessed 28 March 2017].

[5] Nave, C.R. (2012) *Uranium 235 Fission.* [Online] Available at: http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/U235chn.html#c1 [Accessed 1 March 2017].

[6] Wellerstein, A. (2013) *Kilotons per Kilogram.* [Online] Available at: http://blog.nuclearsecrecy.com/2013/12/23/kilotons-per-kilogram/ [Accessed 28 February 2017].

[7] Malik, J. (1985) *The Yields of the Hiroshima and Nagasaki Nuclear Explosions,* Los Alamos: Los Alamos National Laboratory.

[8] Worldometers.info (2017) *Current World population.* [Online] Available at: http://www.worldometers.info/world-population/ [Accessed 28 March 2017].

[9] Lerch, I.A. (2010) *Invisible Nukes*. [Online] Available at: https://www.aps.org/publications/apsnews/201010/backpage.cfm [Accessed 1 March 2017].

[10] Nave, C.R. (2012) *Fast Breeder Reactors.* [Online] Available at: http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fasbre.html#c2 [Accessed 1 March 2017].