# Component 4, Part 1
# Hiroshima and Nagasaki: Nuclear Fission

According to Hewitt (1997), within all known nuclei exist both an attractive force known as the nuclear strong force and a repulsive force created by electrical forces. In every known nucleus, with the exception of the uranium atom, the nuclear strong forces dominate, holding the atom together. In the uranium atom, the nuclear strong forces may become compromised if the nucleus becomes elongated or stretched. This elongation is initiated when the uranium atom is hit with a neutron. Stretching of the uranium nucleus beyond a critical point will result in the domination of electrical forces and the eventual split of the nucleus. The process of splitting of atomic nuclei is referred to as nuclear fission (Hewitt, 1997). Figure 1 (http://www.atomicarchive.com/Fission/Fission1.shtml) is a graphic of nuclear fission depicting the bombardment of a Uranium-235 nucleus by a neutron and the resultant products. Uranium-235 is the naturally occurring fissionable isotope, the most unstable, and therefore the most likely atom to be fissioned.

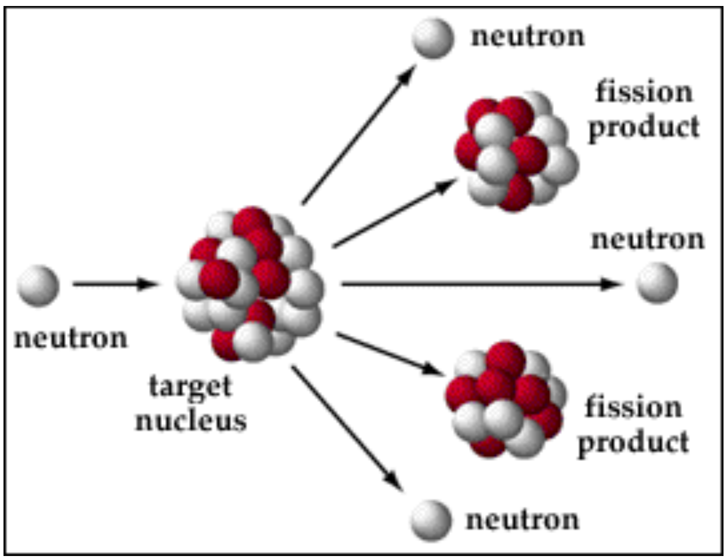


Figure 1 Graphic credit: Atomicarchive.com

It is important to note that fission is not exact. Although the graphic in Figure 1 shows the formation of two daughter nuclei, this is not always the case. In some rare cases, three daughter nuclei result. In any case, the daughter nuclei are rarely identical in mass since the velocity of the bombarding neutron influences the masses of the resulting daughter nuclei. Also created, and as shown in Figure 1, are 2 or 3 neutrons, which can also bombard other original nuclei (Clark, 1980). As these next nuclei undergo fisson, they release additional free neutrons which cause more fissioning. This ongoing process is known as chain reaction. Figure 2 is a graphic of a chain reaction of Uranium-235.

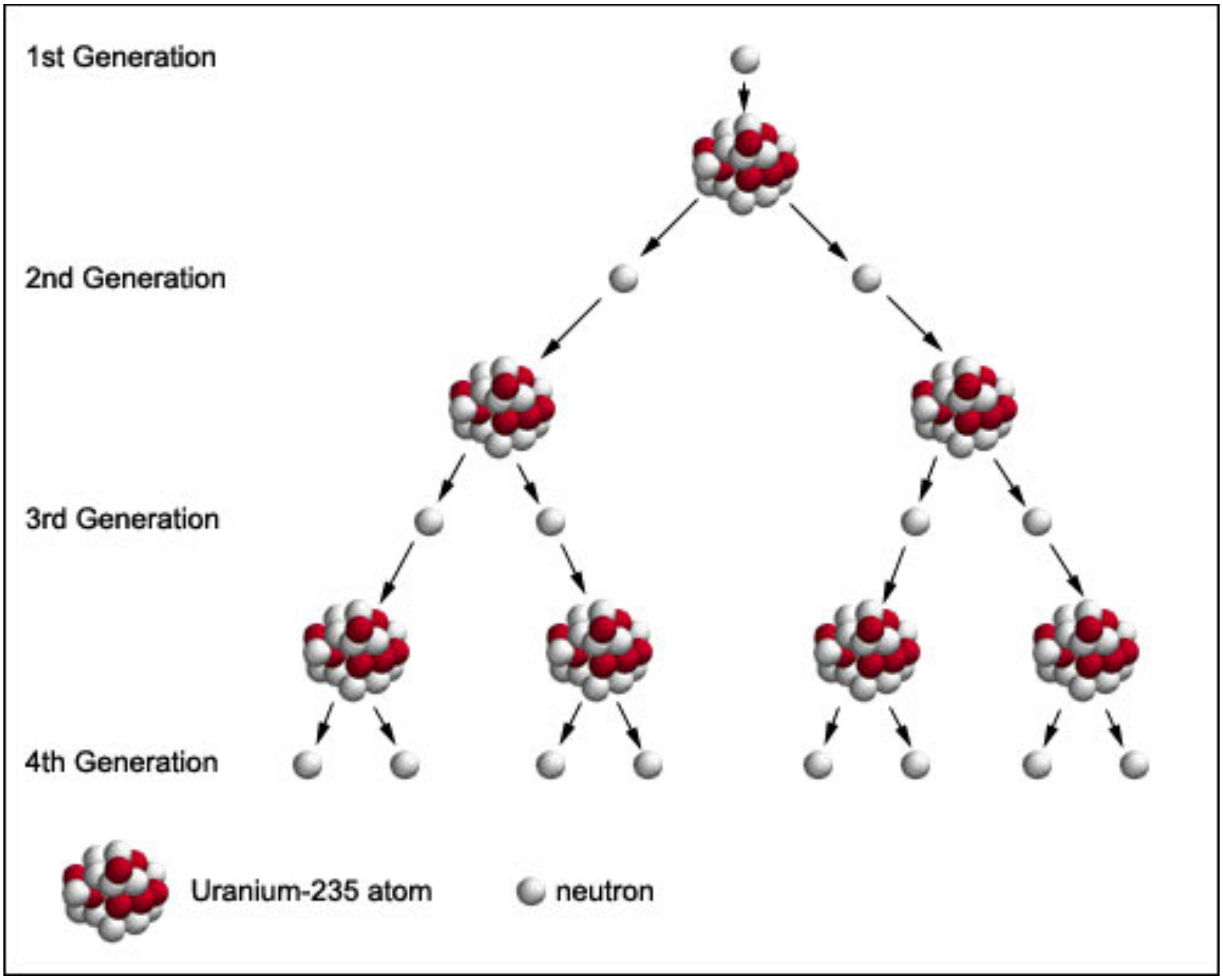


Figure 2 Graphic credit: [Atomicarchive.com]

As a uranium atom splits, energy is released. The amount of energy released depends on the size of uranium targeted. If a chain reaction were to be initiated in a very large chunk of U-235 (say the size of a baseball), the resulting explosion would be massive. But a chain reaction taking place in a smaller piece of U-235 would possibly not produce an explosion. This is because in a smaller piece of uranium, a bombarding neutron could travel to the surface of the material and escape before coming in contact with another uranium nucleus. In a large piece of U-235 a bombarding neutron is much more likely to hit another uranium nucleus, since it can travel farther through the material before surfacing (Hewitt, 1997). If a chain reaction occurs like the one depicted in Figure 2, the number of fissions doubles after each generation (atomicarchive.com). It is important to note however, that not every neutron produced in a chain reaction is used to continue the reaction. Some are lost. If the reaction produces enough usable neutrons then it has reached critical mass, or has become self-sustaining (Clark, 1980).

**Note To Teacher**

Keywords in this part are underlined and in bold:

**Nuclear Strong Force**: Forces present within the nucleus of an atom that serve to hold it

together.
**Nuclear Fission**: The splitting of atomic nuclei.
**Chain Reaction**: A self-sustaining reaction in which one reaction event stimulates at least one additional reaction event to keep the process going.

**References**


A. J. Software and Multimedia (2006). *Atomicarchive.com*. Retrieved October 8. 2006 fromhttp://www.atomicarchive.com/Fission/Fission2.shtml.

Clark, R. W. (1980). *The greatest power on earth: The story of nuclear fission*. London: Sidgewick and Jackson. Hewitt, P.G. (1997). Conceptual Physics (3rd ed.). Menlo Park, CA: Addison Wesley.


**Additional Resources**

Links to websites depicting graphical representations of the process of fission:
http://www.atomicarchive.com/Fission/Fission1.shtml
http://library.thinkquest.org/3471/nuclear_energy_body.html

Links to middle/high school lesson plans on nuclear fission:
http://www.sciencenetlinks.com/Lessons.cfm?DocID=40 (Splitting the Atom: grades 9-12)http://school.discovery.com/lessonplans/programs/savagesun/ (Understanding the types of nuclear reactions: grades 9-12)http://school.discovery.com/lessonplans/programs/actinide/ (The Actinide Series: grades 9-12)

# Component 4, Part 2
# The Atomic Bombs—Hiroshima and Nagasaki

As we learned in Part 1, a sustained nuclear fission (with critical mass) reaction in U-235 can result in a massive explosion if enough uranium material is involved. In the case of the atomic bomb dropped on Hiroshima, U-235 was the fissile material utilized. Within the bomb, U-235 was divided into two sections, both being below critical mass (to keep the bomb from exploding as soon as it was constructed). A detonating device was used to unite the two sections, causing an immediate explosion. This bomb was named "Little Boy" for President Franklin Delano Roosevelt. A different procedure and nuclear material was utilized in the production of the bomb dropped on Nagasaki. Plutonium-239 was the fissile material. It was divided into several subsections within the bomb's housing and surrounded by gunpowder. Once detonated, the plutonium subsections were squeezed together, thus creating the critical mass necessary for a chain reaction and explosion. This bomb was named "Fat Man," for England's Prime Minister, Winston Churchill. Figure 1 provides a comparison of the two different bombs dropped on Hiroshima and Nagasaki (The Nagasaki Peace Declaration, 2006).