**Nuclear Power**

**Activity 4: The Alternative Thorium Fuel Cycle**

ost research in nuclear power is focused on the U-Pu fuel cycle. There is, however, an alternative cycle based on thorium. Thorium has one long-lived, radioactive isotope thorium-232 (232Th). Along not fissile itself, 232Th can be transmuted to uranium-233, which is fissile. The major advantages of a thorium-based nuclear fuel cycle include: thorium is more abundant than uranium (6x); all material mined is used to produce energy as opposed to uranium in which on 0.7 % of the mined material is a fuel; few long-lived transuranic elements in the spent fuel; and reduced radioactive wastes. Countering these advantages are high fuel fabrication costs, some proliferation concerns, and technical problems associated with fuel reprocessing. Still considerable interest is being expressed in future research on a commercialized thorium fuel cycle. In particular, India is conducting major research on this cycle and China has signed an agreement with Canada to test thorium in a CANDU reactor in Quinshan. This activity will explore some of the nuclear physics of a thorium nuclear fuel cycle.

heavy elements.tif

1. 233U is breedby in a thermal reactor from 232Th, the single long-lived isotope of thorium. Map out this nuclear synthesis on the portion of the nuclide chart shown below.

NCdec_Pu-production.gif

1. Write the nuclear reaction(s) describing the production of 233Ufrom 232Th.



1. During the production of 233U, 232U is also produced by a variety of nuclear reactions in the core. Use the interactive Nuclide Chart (<http://www-nds.iaea.org/relnsd/vchart/index.html>) to explore the decay chain for 232U.
   1. What is the primary mode of decay in this chain?

**alpha decay**

* 1. What is the final stable isotope of the decay series?

**208Pb**

* 1. Write out the entire decay chain.
  2. Find Tl in the decay chain. This isotope has a half-life of 3 minutes and emits high-energy gamma rays (2.6 MeV). The intense radiation from this as well as other intermediate products in this decay chain damage electronics. Thus, since 232U cannot be separated chemically from 233U, the risk of unauthorized use in nuclear weapons is less.