inherited variation in single-nucleotide polymorphisms (SNPs)—for example, if one DNA stretch with a particular SNP was rare in a higher percentage of Asians than Caucasians, average gene expression in the first group might be lower. It's still not clear whether the SNPs themselves might be regulating gene expression, or whether they travel together with other DNA that's the regulator.

The question now is whether and how these expression differences affect health. One gene, called *UGT2B17*, is deleted more often in Asians than Caucasians and had a mean expression level that was 22 times greater in Caucasians than Asians, the most dramatic variation seen. "That one really stuck out," says Wooding, who notes that this gene is involved in steroid metabolism and, possibly, drug metabolism as well.

Spielman agrees that genes such as *UGT2B17* and others that showed up in the list of 35 should be looked at individually to determine what the expression differences might mean. Next up for his group: examining gene expression in other ethnicities, including Africans, to see what patterns materialize. **–JENNIFER COUZIN**

NUCLEAR WASTE

With Plutonium, Even Ceramics May Slump

A promising idea for immobilizing nuclear waste may not be so solid after all. Researchers have pointed to crystalline ceramics such as zircon as a strong medium for holding plutonium, a fission product in spent commercial fuel and a security risk with a half-life of 24,000 years. But a new study by mineral physicist Ian Farnan of the University of Cambridge, U.K., and colleagues reveals that alpha radiation could break down this ceramic's structure more rapidly than assumed. A zircon mix containing 10% plutonium-239 (^{239}Pu), for example, could become amorphous in just 1400 years—far short of the U.S. containment target of 210,000 years. This experimental finding, experts say, points to a need for more research on alternative forms of waste storage.

Zircon ($ZrSiO_4$) is frequently studied in modeling waste storage because it can contain natural inclusions of long-lived radioactive elements such as uranium and thorium. Some such samples are as old as Earth. The Farnan study, published in the 11 January issue of *Nature*, used nuclear magnetic resonance (NMR) to directly measure the number of silicon atoms displaced by each emitted alpha particle, first in natural zircon containing ^{238}U and ^{232}Th, and then in zircon doped with ^{239}Pu. Previous estimates of such displacement were in the range of 1000 to 2000 atoms; Farnan observed a much larger displacement of about 5000 atoms, indicating that the structure would fail sooner.

Bruce Begg of the Australian Nuclear Science and Technology Organisation calls the Farnan team's work "very significant" but says it does not address the "key question": whether the alpha-induced transformation of ceramic to an amorphous state "has any detrimental impact on the ability of the waste form to lock up plutonium."

Many researchers believe it does. Linn Hobbs of the Massachusetts Institute of Technology Department of Nuclear Science and Engineering says that a form that becomes amorphous can change "the way that various elements are surrounding other elements." This could allow significant "dimensional changes" in the structure, according to Hobbs, which "may or may not have larger leach rates" into the surrounding environment.

The U.S. storage plan for a significant portion of its weapons waste relies on a completely amorphous medium: glass. The U.S. Department of Energy (DOE) is melting radioactive material together with borosilicate glass in a program to immobilize millions of liters of mixed liquid waste at the Hanford Nuclear Reservation near Richland, Washington, and the Savannah River Site near Aiken, South Carolina. DOE chose this "vitrification" option because tank waste is so complex that no single crystal structure could accommodate all its components. However, most of the plutonium and uranium has been removed, so "there's essentially no probability of a criticality event" in vitrified tank waste, says J. Russell Dyer, chief scientist with DOE's Office of Civilian Radioactive Waste Management. The U.K. and France also vitrify reprocessed power-plant fuel, but only after removing the plutonium.

In limbo. Spent reactor fuel at the Idaho National Laboratory awaits its fate.

The biggest reservoir of plutonium-bearing waste is in spent but unreprocessed commercial nuclear power fuel, most of it stored onsite at utility companies, expected to reach 62,000 metric tons by 2010. The federal weapons complex owns about 7000 metric tons of reprocessed weapons waste and spent fuel, also containing plutonium. Experts say that research is needed to narrow down the candidates for optimal plutonium storage.

Vitrification is a "completely unstable" method of storing wastes, says Kurt Sickafus of the Materials Science and Technology Division at Los Alamos National Laboratory in New Mexico. He argues that ceramic forms can be made "highly stable," but not the silicate-based forms such as zircon. He suggests fluorite crystal structures instead because their amorphousness lies somewhere between that of glass and the rigid silicates. This makes them able to tolerate radiation-induced defects without severe disruption of the crystal lattice, he says. Other researchers look to pyrochlores and zirconolites, outgrowths of the work on the titanium-based SYNROC ("synthetic rock") by A. E. Ringwood in the 1970s. U.S. funding for research on ceramic waste forms has been stagnant or declining for years, says Sickafus.

Despite the obstacles, Farnan says the problem is "tractable." However, "if you take a material and ask what its behavior is going to be in 10,000 years, the uncertainties become very large." Even so, there is good news in these findings, Sickafus notes: This "very sensitive and elegant" NMR technique can help whittle down uncertainty about the robustness of alternative materials relatively quickly.

–VALERIE BROWN

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