Fingerprinting DNA from a single hair

A Florida court convicted a man last month on two counts of first-degree murder and necrophilia. Ten days earlier, a U.S. military court had sentenced a serviceman in Korea to 45 years for rape and attempted murder. In both trials, a technique called DNA fingerprinting — used to compare the defendants' genetic makeup with DNA contained in semen found on the victims' bodies — was pivotal in bringing about the guilty verdicts.

By identifying individuals as definitively as do regular fingerprints, DNA fingerprinting promises to revolutionize the analysis of semen, blood, hair and other samples left by criminals. Until recently, however, the forensic use of DNA fingerprinting had been somewhat limited because the method requires micrograms of DNA—that means several hairs, or blood and semen spots in amounts larger than what is often found at a crime scene. Now two research teams, taking different approaches, have developed DNA analyses that can be performed on nanograms of DNA, an amount typically found in a single strand of hair. This is an important benchmark because hair is commonly found at crime scenes.

One technique, devised by scientists at Cetus Corp. in Emeryville, Calif., and at the University of California at Berkeley, can even analyze very old, degraded samples of DNA. This not only enlarges the spectrum of criminal cases in which DNA typing is useful, but also opens the door for some interesting genetic studies in paleontology and archaeology. One Cetus researcher, for example, recently used the technique to examine the genetic sequence of DNA preserved in the muscle of a 40,000-year-old mammoth.

DNA fingerprinting was developed three years ago by geneticist Alec Jeffreys at the University of Leicester in England (SN: 12/21&28/85, p.390). Jeffreys observed that a number of DNA segments contain particular sequences of bases, the DNA building blocks, and these sequences are repeated many times. Most important, he noted that the number of repeat sequences in each of these regions —and hence each region's length—varies from one person to the next.

Jeffreys devised a technique that first cuts DNA into fragments. These are arranged according to length by electrophoresis, and then the ones that contain repeat sequences are tagged with radioactive probes, which allow these fragments to be visualized. The resulting pattern, which resembles a supermarket bar code, is a DNA fingerprint. With this method, the chances of two unrelated people having the same DNA fingerprint are, on average, 1 in 30 billion.

But in spite of its unusually high discriminating power, this approach has some drawbacks for forensic work: It requires relatively fresh samples and relatively large amounts of DNA. Addressing the second problem, Jeffreys and researchers at Cellmark Diagnostics — the company that licenses the DNA fingerprinting patent — recently announced a modified, more sensitive technique. Instead of using the original repeat-sequence probes, which are relatively short molecules, the researchers made new "locus-specific" probes out of selected DNA fingerprint fragments. These larger probes are able to carry more radioactivity, enabling researchers to detect DNA at levels as low as 20 nanograms. This allowed the group to use the technique on a single hair root, according to Cellmark's David Green in Germantown, Md.

Scientists at Cetus have devised an even more sensitive technique and have used it to type samples containing less than 1 nanogram of DNA. In fact, they can work with as little as a single DNA molecule. Their method relies on a molecular copying process called polymerase chain reaction (PCR) gene amplification, which has been steadily changing the face of molecular biology since it was developed at Cetus three years ago. While traditional methods of copying genes or the proteins for which they code typically take weeks, PCR amplification can produce millions of copies in less than a day.

In the April 7 NATURE, Cetus' Russell Higuchi and Henry A. Erlich, along with Cecilia H. von Beroldingen and George F. Sensabaugh at the University of California at Berkeley, report that they have applied the PCR method to forensic samples of DNA. From both fresh and shed hairs, the researchers succeeded in making enough copies of one small DNA region, a portion of a gene, to perform three kinds of typing on it. By looking at differences in the length and/or base sequence of that gene, they could classify individuals into 21 different types. Unlike the Cellmark method, which requires long, intact DNA chains, the Cetus technique can copy and type DNA that has been degraded by long exposure to light or enzymes. The researchers typed several-month-old fallen hairs in which they had been unable to detect any DNA with conventional chemical means, and the group is currently working with police on DNA samples that are several years old.

Shed hairs typically contain less than 10 nanograms of DNA, and being able to type them is particularly important "because they're the most common hairs found in forensics," Higuchi says.

For both techniques at this stage, the cost of greater sensitivity is lower precision in distinguishing one person from another. Green estimates that with a test made of four of the new locus-specific probes, the chances of two people having the same pattern would be 1 in a million, on average. (Sometimes the odds are much better: In the Korea case, the serviceman's pattern was so unusual that the statistics were 1 in 4.5 trillion.) The Cetus technique now is far less discriminating. But von Beroldingen expects that by looking at several different genes, her group will achieve comparable values within the next few years.

Because DNA typing can go much farther in zeroing in on a particular individual — as opposed to blood typing and other traditional forensic methods, which can at best simply narrow the field of suspects — both Britain's Home Office and the U.S. Federal Bureau of Investigation (FBI) have been closely following DNA fingerprinting. The FBI is evaluating a number of approaches, including the recent developments, and according to a spokesman, the bureau hopes to incorporate some form of DNA typing into its investigations by early fall.

While DNA fingerprinting figures prominently in a growing number of trials, it still may take some time before U.S. courts embrace DNA evidence as enthusiastically as do investigators and scientists. Right now DNA fingerprinting is being introduced into the courts on a case-by-case and state-by-state basis, says Cellmark's George Herrin Jr.

"It's a new technology, so no one, except the scientists, is really quite sure how to deal with it," he says. "It's thrown the legal system for a loop because it is much more powerful than any ID technique they've had other than normal fingerprints." *— S. Weisburd*

Farthest galaxy is cosmic question

Galaxies are the basic constituents of the universe. When and how they formed are fundamental questions for any theory of cosmology. Astronomers keep looking for ever-more-distant galaxies, because the farther away they are, the earlier the epoch at which we see them. Simon Lilly, a British astronomer working at the University of Hawaii at Manoa, has found a galaxy with a redshift of 3.4, which would put it four-fifths of the way back to the beginning of the universe.

This object, catalogued as 0902+34, is the most distant object now known for which there is good evidence that it is a galaxy. Some astronomers at the University of Arizona recently found infrared objects that seem to have redshifts greater than 6 (SN: 1/23/88, p.52) but have not been able to prove they are galaxies. Redshift, a displacement of the object's emissions toward the red end of the spectrum, is proportionate to the speed at which the object is receding from the observer. Distance can be calcu-