Elements employed to trace smuggled tusks

Trace quantities of radioactive isotopes within ivory trinkets and African elephant tusks can divulge where in Africa those pieces originated, new research indicates. The finding suggests that telltale patterns of nuclear decay within black-market ivory may help conservationists track down hotspots of illegal elephant hunting and stem the decline of the endangered pachyderm.

The technique measures minute concentrations of naturally occurring radioactive elements in biological tissues. Archaeologists and ecologists frequently subject skeletal remains to such isotope analysis to learn about the diets that supported the growth of those bones. The new work applies this technique for the first time to elephants.

Working separately, two groups of researchers analyzed ivory and bone specimens from a total of more than 100 elephants that had died in 10 African countries. (Elephant bones are chemically almost identical to ivory but are easier to find, so the scientists often used them to validate their technique.) Using mass spectrometers, both teams measured the ratio of carbon-12 to its radioactive cousin, carbon-13. They also tallied the relative amounts of nitrogen-14 and radioactive nitrogen-15, and the ratio of strontium-87 to strontium-86. Each of the three isotope ratios describes a different aspect of the elephant's home turf: the climate in which it lived, the plants it ate and characteristics of the soil supporting those plants.

For example, carbon isotope ratios in bones and tusks can reflect metabolic differences in the plants the elephants have eaten. The grasses grazed by savannah-dwelling elephants use what's known as a C_4 pathway – a highly efficient metabolic cascade that starts off with the production of a four-carbon sugar. In contrast, the trees browsed by elephants in wooded regions use the C_3 pathway. This relatively inefficient photosynthetic route starts with production of a three-carbon sugar. Since the C_3 pathway involves a greater number of carbon-adding steps – each discriminating against the heavier, more cumbersome isotopes – C_3 plants accumulate less carbon-13 than do C_4 plants. Ultimately, this inequity shows up in the tissues of tree-browsing elephants, providing a neat atomic signature of their diet.

Similarly, differences in climate – particularly rainfall – affect nitrogen isotope ratios in plants and plant feeders, although the mechanism remains poorly understood. And strontium isotope ratios in soil vary with the geologic age of the rock below. Strontium ratios become incorporated into the plants that grow there and can be measured in the skeletons of plant-eating animals.

In the new research, archaeologist N.J. van der Merwe of Harvard University and the University of Cape Town, South Africa, measured isotope ratios in bones and tusks collected by officials in African game refuges. With colleagues in South Africa, Zambia and Namibia, van der Merwe found statistically significant differences between isotope ratios among elephant remains from 20 sites in 10 nations. In some cases they could discriminate between elephants found within 150 kilometers of each other.

"We conclude that . . . isotopic analysis provides a potential means of identifying source areas of ivory on a wide geographic scale," the researchers write in the Aug. 23 NATURE. They suggest that scientists compile a comprehensive index of ivory isotope signatures for all regions where elephants still exist in Africa. "Such a database could provide the foundation for international control of the ivory trade and hence for the conservation of the elephant and its habitat," they say.

In the same journal, J.C. Vogel and colleagues at the Council for Scientific and Industrial Research in Pretoria, South Africa, describe similar experiments performed on ivory and bone specimens in Namibia and South Africa. They derived additional data from lead isotope ratios, which, like strontium ratios, vary with underlying rock types. "There would have to be a more complete survey of elephant habitats in the rest of Africa before the technique can be applied on a wide scale," they note. "In principle, however, these isotope fingerprints in ivory can make a positive contribution towards monitoring the products of the endangered African elephant."

John C. Patton, a biologist at Washington University in St. Louis, agrees that the technique shows promise. But he notes that preliminary results from his laboratory suggest DNA analysis of elephant tusks can reveal not only the locality from which the specimen was taken, but also information about elephant genetics and population biology that may ultimately prove useful in captive-breeding efforts (SN: 2/4/89, p.72).

The number of African elephants has dropped from more than 1 million to about 600,000 in the past 10 years. In January 1990, African elephants joined the ranks of the officially endangered, as defined by the Convention on International Trade in Endangered Species, a treaty organization that seeks to regulate trade in rare plants and animals. A few African nations still allow limited ivory trade because their local elephant populations are doing well. But trade restrictions remain difficult to enforce without a way to determine the true origins of ivory products. *– R. Weiss*

Award-winning links twixt math and physics

Mathematicians at a major international conference this week in Kyoto, Japan, turned the spotlight on four members of their community by awarding each a Fields Medal. Among mathematicians, the award – first presented in 1936 and now given every four years at the International Congress of Mathematicians – carries the prestige if not the monetary value of a Nobel Prize.

Medalist Vaughan F.R. Jones, 37, a topologist at the University of California, Berkeley, is best known for his work in knot theory (SN: 5/21/88, p.328). In 1984, he unexpectedly discovered a connection between von Neumann algebras (mathematical techniques that play a role in quantum mechanics) and knot theory. That link led Jones to formulate an improved method for distinguishing among knots. The discovery also generated a great deal of activity in the mathematical community and prompted renewed speculation about connections between knot theory and physics.

The work of award winner Edward Witten, 39, of the Institute for Advanced Study in Princeton, N.J., illustrates how blurred the distinction between theoretical physics and mathematics can get. Witten, better known as a physicist, is one of the chief proponents of string theory, which attempts to provide a unified picture of gravity and quantum mechanics. He contends that string theory will ultimately flourish as a new branch of geometry. Witten's recently developed "topological quantum field theories" hint at what such a geometrical foundation would look like (SN: 3/18/89, p.174).

Shigefumi Mori, 39, of Kyoto University, has devoted much of his career to pioneering methods of classifying certain kinds of surfaces defined by algebraic equations, thereby extending the classical theory of algebraic surfaces to three dimensions.

Award winner Vladimir G. Drinfeld, 36, of the Institute for Low Temperature Physics and Engineering in Kharkov, USSR, has contributed significantly to the fields of algebraic geometry and number theory, proving several fundamental conjectures in number theory and introducing a number of concepts useful in other fields.

Unlike Nobel Prizes, the mathematics awards go only to individuals who are "less than or equal to" 40 years of age. The emphasis on youth is designed to encourage recipients to continue their research while recognizing novel ideas that open up new mathematical frontiers for others to explore. *– I. Peterson*