Any Horse Trader Could Have Told You

Racemization of amino acids in teeth and eye lenses make it possible to tell the ages of humans and animals

Radiocarbon dating and other similar techniques have proved invaluable for determining the age of archeological artifacts. Most developments, such as the use of accelerators for counting individual atoms of carbon-14 (*Science*, 12 May 1978, p. 635), have been directed toward ascertaining the ages of ever older objects. Now, however, Jeffrey L. Bada and Patricia M. Masters of the Scripps Institution of Oceanography have refined one of the techniques, amino acid racemization, so that it can be used for determining the age of animals as young as 10 years old. Their technique shows promise of resolving, once and for all, the dispute among gerontologists about the claimed ages of long-lived individuals in Ecuador and Soviet Georgia.

Dating by amino acid racemization, originally developed by Bada and others almost 10 years ago, relies on the fact that the proteins of all living organisms are composed of amino acids with a specific, asymmetric spatial configuration. Chemically synthesized amino acids, in contrast, ordinarily contain equal quantities of these L-isomers and their mirror image D-isomers. Over a period of time, pure L- or D-amino acids undergo a temperature-dependent change in configuration, known as racemization, in which L-isomers are converted to D-isomers and vice versa until, at equilibrium, the isomers are present in a fixed ratio. Bada demonstrated that, if the temperature history of a fossilized object of biological origin is known, the amount of racemization that has occurred can be used to determine the age of the object with relatively high precision. Using the technique, he has dated archeological finds ranging in age from a few thousand to more than 500,000 years old.

Amino acids in animal tissues also racemize, but most are replaced with newly synthesized proteins at regular intervals so that the total amount of racemization remains small. Some proteins, though, are synthesized at or near birth and are never replaced. In the course of her research, Masters speculated that amino acids in such proteins would racemize during the animal's lifetime and that the amount of racemization could be used to determine the animal's age. This proved to be the case for both dentine from teeth and lenses from the eye.

At the normal temperature of the human body, aspartic acid—which is the amino acid used for most of the age determinations—racemizes at the rate of about 0.14 percent per year in the lens and about 0.1 percent per year in dentine. The proportion of D-aspartic acid in the dentine or lens is determined by hydrolyzing the protein, isolating aspartic acid by anion exchange chromatography, and derivatizing it so that the D- and L-forms can be separated and quantified in an amino acid analyzer. Fortunately for the investigators, both lenses and dentine contain relatively high concentrations of proteins, so one tooth or one lens is more than enough for analysis. Values for ages obtained by the technique are accurate to within 10 percent, Masters says.

The technique is still new, and there have been only a few applications. In one of the first applications Masters determined the age of an Eskimo woman whose remains were recovered from the permafrost on St. Martin's Island. Radiocarbon dating showed that the woman died about 1600 years ago, and physiological evidence from the well-preserved corpse suggested that the woman was between 50 and 60 years old at death. Because the corpse had been frozen, Masters says, no further racemization occurred. Using one of the corpse's teeth supplied by M. R. Zimmerman of the University of Michigan, Masters confirmed that the woman was 53 years old when she died. The Scripps workers are also using the technique to determine the age at death of individuals buried in a medieval cemetery in Czechoslovakia, where local persistent cold temperatures impeded postmortem racemization.

Amino acid racemization could be used to determine the ages of long-lived individuals, such as this resident of Vilcabamba, Ecuador. [Photo courtesy of Mirette Seireg, University of Wisconsin]

Perhaps the most noteworthy application of the technique, though, was demonstrated recently in association with Vera Rubin of the Research Institute for the Study of Man. With her help, Bada and Masters received from four visiting Soviet gerontologists the tooth of a Georgian woman whose age was documented to be 96. The Scripps pair, with no prior knowledge of the woman's age, determined it to be 99 years, well within the promised accuracy. The Soviets subsequently promised to provide more samples of teeth and lenses, when they are available, from Georgians whose ages are not as well authenticated. The pair also hope to obtain samples of teeth or lenses from residents of Vilcabamba in Ecuador who are also reported to be exceptionally long-lived. Results from such studies should finally settle the arguments about the claimed longevity of those individuals.

In another potential application, Bada and Masters have made a preliminary study of teeth from whales, porpoises, polar bears, and elephants. By determining the ages of single individuals in groups of such animals, Bada says, it should be possible to get a better estimate than is now available of the reproductive potential of the group as a whole. This information could then be applied in management decisions affecting endangered species.

In one unexpected development, Masters, Bada, and J. Samuel Zigler of the National Eye Institute, have observed that there is a correlation between accelerated racemization in eye lens proteins and a form of human eye disease known as brunescent cataracts. In this type of cataract, the lens develops dark brown or black pigmentation. Preliminary results do not yet indicate whether accelerated racemization is a result of pigment formation or is a causal factor, but further studies should provide information concerning the origin of cataracts. Meanwhile, the Scripps group is looking for still other applications for this very unusual technique.—THOMAS H. MAUGH II

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