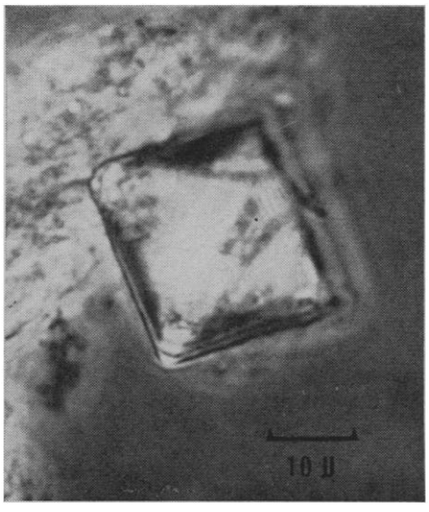

Fig. 2. Photomicrograph of a typical yellowish-brown, octahedral ferritin crystal (about × 1100).

eralization occurs by intussusception from the cells of the dorsal epithelium in the radular sac (*10*). Histochemical studies of the dorsal radular epithelium from several species of chitons have revealed the presence of iron granules which stain specifically for ferric iron (*11*). We considered that these iron granules might contain ferritin and therefore studied, with an electron microscope, the upper epithelium of the radular sac in contact with the denticles, from the species *Cryptochiton stelleri*.

The entire radula was removed from a mature individual (*12*) and immediately fixed in cold, 2-percent osmium tetroxide buffered with veronal acetate. After 2 hours in the fixative the radula was run through a series of graded alcohols. When in 70-percent ethanol, the immature teeth and associated tissues were carefully excised from the distal portion of the radula and trimmed. The teeth were embedded in Epon 812 from absolute ethanol after infiltration with propylene oxide. The resin was polymerized at 60°C. Sections were cut with glass knives on an LKB Ultrotome and examined in a Philips EM-200.

Study of the columnar epithelial cells of the dorsal wall of the radular sac revealed the presence of numerous dense, granular bodies situated 6 to 8 μ from the contact between the cells and the wall of the radular tooth. Closer inspection of electron micrographs enabled us to classify these circular and oval bodies as either crystalline or paracrystalline types (Fig. 1 and the cover picture, respectively). The paracrystalline forms occur more frequently. The granules in these bodies are morphologically identical to normal ferritin (*13*). The iron micelles measure 55 to 60 Å across and, under certain conditions of orientation, characteristic subunits are sometimes resolved (Fig. 1, inset). In addition, the molecular micellar lattice (<30 Å) can be seen in the left-central portion of the ferritin crystal of Fig. 1.

Small amounts of the ferritin were isolated from the extracts of the dorsal epithelial cells from several radulae by Granick's modification (*14*) of Laufberger's original method (*2*). Minute, yellowish brown, octahedral crystals (Fig. 2) formed after several days in 5-percent cadmium sulfate solution. The characteristic ferritin crystals were soluble in 2-percent ammonium sulfate and could be recrystallized in 5-percent cadmium sulfate.

Work is in progress to characterize further this invertebrate ferritin and to establish its relationship to the formation of the magnetite of the radular teeth. In view of its occurrence in these primitive molluscs and in polychaete worms we are in agreement with Hyde *et al.* (*7*) who feel that ferritin is an ancient protein from an evolutionary standpoint. It will probably also be found in a variety of other invertebrates (*15*).

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Cesium-137 in Alaskan Eskimos

Abstract. *During the summer of 1962, levels of radioactivity in over 700 people at four villages above the Arctic Circle in Alaska were measured with a transportable whole-body counter. The averages for body burden of cesium-137 were much higher than the average for people in the rest of the United States. The people of the interior village of Anaktuvuk Pass had the highest average burden of cesium-137, which was 421 nanocuries; the maximum burden was 790 nanocuries.*

Members of the Hanford Laboratories have participated since 1959 in a bioenvironmental study program in the Cape Thomson area of northern Alaska as part of the Atomic Energy Commission's Project Chariot. One of the early results of these studies was the discovery of high levels of cesium-137 in lichens and caribou. This finding stimulated interest in the body burdens of isotopes from fallout in Eskimos in that area. Attempts to obtain autopsy samples of these Eskimos met with very limited success. In the fall of 1960, high body burdens of Cs^{137} were discovered in Norwegians (*1*) and subsequently in Swedish Lapps (*2*). The high burdens in these Lapps were thought to be connected with the food chain—from lichen to reindeer to man. During this period, a shadow-shield whole-body counter was developed at the Hanford Laboratories for other purposes. This counter was light and was so constructed that it could be readily transported.

During the summer of 1962 the counter was taken to northern Alaska, and the body burdens of over 700 people were measured. The counter was taken to the coastal villages of Kotzebue, Barrow, and Point Hope and to Anaktuvuk Pass, a village in the heart of the Brooks Range. Counts

were made for Eskimos from Little Diomede Island while they were at Kotzebue.

Table 1 gives the average, minimum, and maximum burdens of Cs^{137} for permanent Eskimo residents of the villages studied. The average body burden of Cs^{137}, for individuals from whom counts were made with the Hanford whole-body counter at Richland, Washington, during the same period, was 5 to 7 nanocuries [1 nanocurie (nc) = 10^{-9}c]. Thus, the average burdens for the Eskimos were 3 to 80 times the Richland average. Some of the burdens for the Eskimos were comparable to those found for the Lapps. In the first measurements for Swedish Lapps, counts as high as 361 nc were obtained (*2*). A later, more extensive study of Finnish Lapps showed similar high burdens (*3*). Among those Lapps who made their living by raising reindeer, the average burdens for men and women were 245 and 121 nc, respectively, with maxima of 790 and 299 nc.

The International Committee on Radiological Protection recommends that the maximum permissible body burden of Cs^{137} be set at 3.0 μc for individuals in the population at large who are not exposed in the course of their occupation (*4*). No specific recommendation was made concerning average levels of Cs^{137} for groups such as the Alaskan Eskimos.

All of the subjects of the study were questioned at length about their diet. Environmental and food samples were collected, and counts of the samples on special holders in the shadow-shield whole-body counter were made, or the samples were subjected to examination in the laboratory. A comprehensive ecological study of these Alaskan communities based on these data, on the results of whole-body counting of individuals, and on data obtained in previous years is being prepared. In general, however, it appears that the high body burdens in the human beings can be correlated with high levels of Cs^{137} in reindeer and caribou, and that the high levels in the animals are produced by high levels accumulated in lichens. At Anaktuvuk Pass, caribou meat constitutes a major part of the diet. At Kotzebue, much reindeer meat, from nearby domestic herds, is consumed. The other villages subsist more on seafood than on caribou; seafood generally contains little Cs^{137}.

At Kotzebue, counts were made for 20 natives from ten nearby villages when they came in for treatment at a Public Health Service hospital. The body burdens were similar to those found for residents of Kotzebue, but the differences were sufficient to suggest significant dietary differences between villages.

Table 1. Body burdens of cesium-137 in permanent Eskimo residents of Alaskan Eskimo villages.

Village	No. of subjects	Body burden of Cs^{137} (in nc)				
		Min.	Max.	Averages		
				Males and females	Males	Females
Point Hope	107	3	119	17	20	13
Diomede	12	8	35	22		
Barrow	259	8	166	52	66	40
Kotzebue	132	17	518	138	147	118
Anaktuvuk	52	83	790	421	474	343

The school system maintained for the Alaskan Eskimos requires that the children of high school age be away from home at boarding schools from September through May of each year. The measurements of our study were made during the period when the students were at home, and counts for 70 of them were made. On the average, the body burdens for the students were found to be about one-fifth those for the permanent residents of their villages. At school, the students' diets consist almost exclusively of food shipped in from outside Alaska, which has a relatively low Cs^{137} content. The students' body burdens of Cs^{137} decrease during the school year (the effective half life of cesium in the body is about 100 days) and increase during the summer months; on the average, the students have a lower body burden than they would have if their diet were the same as that of the permanent residents the year round.

At both Barrow and Kotzebue there were some non-Eskimos who did not eat any significant amounts of native food. Counts were made for 14 such people at Barrow and for 25 at Kotzebue. Their body burdens of Cs^{137} were similar to those of people in the rest of the United States; the averages were 6 and 7 nc, respectively, at Barrow and Kotzebue. Two non-Eskimos at Barrow and 29 at Kotzebue who did eat native food rather regularly had average body burdens of Cs^{137} of 35 nc.

No radioisotopes other than Cs^{137} and potassium-40 were detected in the Alaskans except in two subjects who had body burdens of a few nanocuries of zinc-65. These people occasionally ate canned oysters, and this probably accounts for the presence of the Zn^{65} (*5*). External body contamination, mainly of zirconium-niobium-95, was noticed frequently. There were no facilities for having the Eskimos take showers before counts were made, but they did change from their own clothes into paper shirts and pants. The interference from this Zr-Nb^{95} of external origin was minor, and correction for it was easily made. The amounts of K^{40} found in the Eskimos were slightly higher than those found in people measured at Richland, Washington; this probably indicates that the Eskimos are slightly more muscular than the residents of Richland. The variation in the level of K^{40} with age in the Eskimos was similar to the variation measured at Los Alamos, New Mexico (*6*).

The shadow-shield whole-body counter used in this study is described elsewhere (*7*). It was calibrated for measurement of K^{40}, Zn^{65}, and Cs^{137}. For these isotopes the calibration showed little dependence on the size of the person being measured. The shield consists of about 5 tons of lead bricks. These were conveniently packaged for shipment and then reassembled at each village. North of the Arctic Circle, all the equipment was carried by air. The shield was placed in existing buildings or outside on a foundation resting on the permafrost (*8*).

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Cesium-134 in Alaskan Eskimos and in Fallout

Abstract. *Whole-body counts of Alaskan Eskimos during the summer of 1962 showed the presence of cesium-134 as well as cesium-137. Cesium-134 was also found in reindeer and caribou meat; this finding was confirmed through coincidence counting. There was generally about 1 percent as much cesium-134 as there was cesium-137. Cesium-134 was also found on air filters collected at Richland, Washington. The appearance of cesium-134 seems to be world-wide and continuing.*

In the first report of the finding of cesium-137 in Laplanders (*1*), mention was made of a small peak at 800 kev in the scintillation-counter pulse-height spectrum. After further study, Lidén and Andersson (*2*) concluded that the peak was caused by Cs^{134}. The identification was made through coincidence counting and half-life measurement. The Cs^{134} was found both in people and in reindeer meat, in the same abundance relative to Cs^{137}. In measurements made in March 1961, about 1.6 percent as much Cs^{134} as Cs^{137} was found.

The same Cs^{134} peak was found in the spectra for some Alaskan Eskimos during the work described elsewhere in this issue. Figure 1 shows the average spectrum for the ten Eskimos with the highest body burdens of Cs^{134} found in the 1962 study. The peak is clearly visible. It is also visible in the spectra for the individual Eskimos of this group, particularly in the spectrum for the individual with the highest body burden (790 nc) of Cs^{137}, but more significant statistics are obtained by averaging the spectra.

All of the individuals in this high-body-burden group were from Anaktuvuk Pass. The average spectrum for all the people of Anaktuvuk Pass for whom counts were made showed the Cs^{134} peak, but it was not so well resolved in this spectrum as in the average spectrum for the high-body-burden group. The peak could not be clearly identified in spectra for individuals or groups from other parts of Alaska. We feel that the statistical uncertainties in the count for the low-body-burden groups and the interferences of low-level radiation from $Zr\text{-}Nb^{95}$ from external sources were large enough to conceal a peak even if there were one.

The average spectrum for 200 people for whom counts had been made with the Hanford whole-body counter at Richland, Washington, in 1961 was computed to see if any evidence for the occurrence of Cs^{134} could be found. (The period of counting had been 20 minutes instead of 5 or 10, as in the 1962 study of the Eskimos.) Again, the statistical uncertainty stemming from K^{40} and Cs^{137} contributions to the spectrum in the region where the Cs^{134} peak would occur was large enough to conceal such a peak.

Comparison of photo-peak heights for the Eskimos and correction for gamma-ray abundances and for efficiency and resolution of the counter gave a Cs^{134}/Cs^{137} activity ratio of 0.0118. Comparing the average spectrum for the Eskimos with the spectrum for Cs^{134} and Cs^{137} sources dissolved in water gave a ratio of 0.0125. The counts for the Eskimos were made in July 1962. Correction for decay of the two isotopes gives an activity ratio of 0.018 for March 1961. This value is in reasonable agreement with the ratio found in Lapland.

Counts for reindeer and caribou meat collected in Alaska in the summer of 1962 also showed the presence of Cs^{134}. Findings for the Cs^{134} content of these meat samples were verified and measured by gamma-gamma coincidence counting of the 0.605- and 0.797-Mev cascade photons, in the manner reported by Lidén and Andersson. Two sodium iodide (T1) scintillators, 23.8 cm in diameter and 9.2 cm thick, were used for counting 1.4-kg meat samples. The coincidence spectra obtained in this manner were compared with the spectrum for a standard Cs^{134} source of similar geometry. These measurements showed the Cs^{134} to be present in a concentration 0.82 percent that of the Cs^{137}.

Cesium-134 has also been found in fallout at Richland, Washington. Cesium

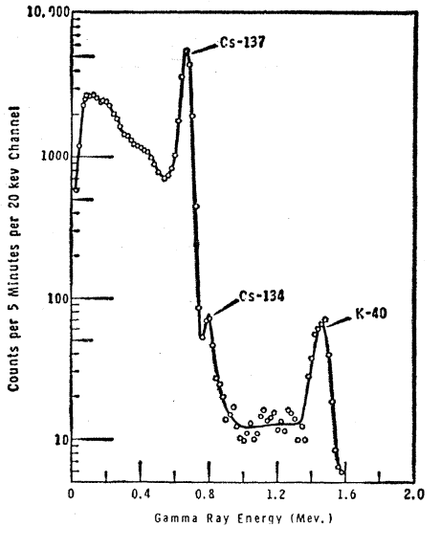

Fig. 1. Average scintillation-counter pulse-height spectrum for the ten Eskimos with the highest body burdens of Cs^{134} found in the 1962 study.

was separated chemically from an air filter which had been in service in 1960. The Cs^{134}/Cs^{137} activity ratio was less than 0.01 (the total activity was too low to permit precise measurement). An activity ratio of 0.017 was found for cesium chemically separated from an air filter that was in service from early December 1962 through February 1963. Although Cs^{134} is produced in nuclear reactors, there is no reason to suspect that the Hanford plant was the source of the Cs^{134} on these filters. The ratioactivity found on the filters is comparable with that found on other filters throughout the Pacific Northwest.

The foregoing data indicate that Cs^{134} has been and is being deposited in North America as well as in northern Sweden and Finland, and that the deposition is probably world-wide. Cesium-134 has been reported in fallout elsewhere. Particulate samples collected from air over St. Louis during March 1957 showed rates of disintegration for Cs^{134} that were from 12 to 16 percent of those for Cs^{137} (*3*). Cesium-134 was also found in a soil sample taken near ground zero after an atomic balloon shot in Nevada (*4*). No Cs^{137} was observed in this sample, so the Cs^{134} evidently resulted from neutron activation of inert Cs^{133} in the soil. It seems unlikely that the Cs^{134} in the St. Louis sample could have been produced by activation of Cs^{133} in soil.

The world-wide distribution of Cs^{134} has an important bearing on the identification of its source. The formation, from fission of uranium-235, of Cs^{134} at concentrations 1.6 percent those of Cs^{137}