ration of the extraction considered. The intercepts can be used to estimate quantities of forms of silica with different solubilities in the samples. Placeritos samples apparently contain 180 μg of a readily soluble form of silica per gram (H_4SiO_4), 220 $\mu g/g$ of a second form of silica of lower solubility, and 500 $\mu g/g$ of a third type. For the Humboldt silty clay loam, the corresponding figures are 150, 240, and 860 $\mu g/g$. In comparison, the saturation pastes used to determine the heat of solution showed 19 $\mu g/g$ from Placeritos silt loam samples and 25 $\mu g/g$ from the Humboldt silty clay loam samples. Approximately one-tenth of the solid silicic acid on the surface of the soil samples was sufficient to produce an equilibrium level of silica in the soil paste. At least one more slope would be anticipated in the extraction curve, since the solubility of quartz, approximately 6 parts per million, had not yet been reached. Under natural conditions of much slower extraction by downward moving water, equilibrium could be expected between silicic acid and the second and third types of silica postulated here as well as with quartz. The origin of the second and third types of silica is not clear: it could possibly be amorphous silica of plant origin or perhaps from the volcanic ash prevalent in northwestern Nevada.

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11 May 1964

Accuracy of Bone Mineral Measurement

Abstract. *The use of nearly monochromatic radiation (I^{125}) for the direct determination of bone mineral absorption in cadaver materials indicates that underlying bone components can be measured accurately on the flesh-covered forearm. The correlation of the bone mass, determined by this scanning technique, with actual bone weight is 0.96. The method is the most accurate yet demonstrated for bone with overlying tissue, and may prove suitable for these studies in vivo where it has not been possible to use previous roentgenologic techniques.*

An improved method for measuring bone mineral in vivo, in which direct measurement is made of monochromatic photon absorption, was described by Cameron and co-workers (*1*). Theoretically, the use of monochromatic radiation should reduce the large uncertainties of the absorption coefficients associated with polychromatic x-ray beams used in other techniques. Use of a well-collimated radioisotope source and a collimated scintillation detector both reduces the effects of scattering and eliminates the film errors of roentgenographic densitometry. The results of preliminary investigations with Cameron's technique have indicated that the theoretical expectations are justified and that accurate estimates of bone mineral content may be made on flesh-covered extremities.

A number of other techniques for determining bone mineral content in vivo are now being used in laboratories here and in other countries. The most common are those based on transmission of polychromatic x-radiation as estimated by film densitometry. Several such methods were developed at the Pennsylvania State University (*2*), and have been shown to be accurate for excised long bones, but when bones with greater overlying tissue than the phalanges are used a substantial error is introduced (*3, 4*). This error is not eliminated by either statistical or experimental control, and is apparently due to the polychromatic radiation, scattering, and film errors. The lack of accuracy restricts the use of the older densitometric methods for studies in vivo which might be of nutritional, gerontological, or clinical interest (*3, 5*).

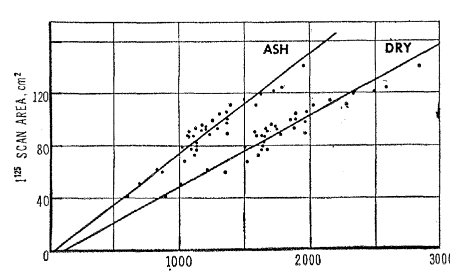

Fig. 1. The I^{125} scan area on the flesh-covered forearm plotted against the ash weight (ASH) and the dry fat-free weight (DRY) of 1-cm sections of underlying bone ($n = 35$).

In the method developed by Cameron (*1*), a collimated I^{125} photon source (27.3 kev) is passed across a forearm and the transmission measured with a collimated scintillation crystal, pulse height analyzer, and scaler. Transmission counts are recorded from the scaler for 7-second periods at each 1-mm interval across the forearm. Logarithms of these counts are plotted at equal intervals on semi-logarithmic graph paper. The two smooth curves representing tissue absorption and bone absorption are drawn through the plotted points, and the area between the two curves is measured by planimeter. The scan area determined in this manner is theoretically proportional to the cross-sectional bone absorption and hence proportional to the mass of bone mineral in the line traversed during the scan.

We have determined the areas for 35 scans across the radius and ulna on two cadavers. Form-fitting pieces of tissue-equivalent material (Mix-D), of the same composition as previously described (*1*), were used as a bolus to maintain equal "tissue" thickness across the forearm. Overlying flesh was removed after the scans were made, and at each of the scan locations 1-cm sections were accurately cut from the bone on a milling machine. These sections were defatted in acetone for over 48 hours, dried to constant weight, and the dry fat-free weight was determined. The sections were then ashed to constant weight (600°C for 12 hours or 400°C for 24 hours) and the weight of the ash obtained.

The dry fat-free weight and the ash weight are shown in Fig. 1 plotted against the corresponding scan areas of the bone. The lines showing the regression of scan area on dry fat-free weight ($Y = 18.3X + 118.3$) and the regression of scan area on ash weight ($Y = 13.0X + 44.3$) are superimposed on the plotted data. The correlation of the scan area, determined with flesh on the bone, with dry fat-free weight is 0.96, and the standard error of estimate is 114 mg. The correlation of the scan area with ash weight is identical, 0.96, but the standard error of estimate of 83 mg is slightly lower. The correlations are, to our knowledge, higher than any of those obtained on flesh-covered human materials, of whatever sort, as determined by previous roentgenologic techniques. Our data show a 6- or 7-percent error of estimate and a total experimental error of 8 percent. This contrasts sharply with the errors in other techniques. Studies of the humerus in cadavers by means of film densitometry have shown an experimental error of from 35 to 50 percent in determinations of bone mineral, and errors are greater still when the femur is studied (*3*). Even on the phalanges (*3*) and the rat femur (*4*), which have a minimal tissue cover, errors of from 15 to 30 percent or more are made with the densitometric method.

In our data the standard errors of estimate are sufficiently small to warrent the use of regression equations, and the regression lines intercept close to the origin, indicating correspondence of the theoretical and empirical relationships. This has also been our finding on excised skeletal bone. Similar scans made on bone phantoms, bones from a modern archeological site, and excised dry fat-free bones have resulted in equivalent or higher correlations (0.97 to 0.99). These findings indicate that the method used is accurate in determining bone mineral content in bones both with and without overlying tissue, and suggest that with further investigations and larger samples the method will provide an adequate means of osseous evaluation in vivo.

The radiation dose from the 5-mc I^{125} source is small in comparison to conventional roentgenography, and the dose is limited to a small area of the forearm (*1*). The method can be extended to areas of the body with greater absorption than the forearm by using I^{125} sources of greater activity, or by using sources with higher photon energies, such as Am^{241} (59.6 kev). Scan areas determined on excised bones, with Am^{241} being used as a source, gave correlations with bone mineral identical to those obtained when I^{125} was used.

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Radio Map of the Andromeda Galaxy

Abstract. *The University of Illinois radio telescope has resolved the 610.5 Mcy/sec disk component of radio emission from the large galaxy M 31 into several discrete concentrations. In two cases, these correspond to the crossing of the optical major axis by spiral arms. A spur of emission extends southeast from the galaxy near the minor axis.*

The earliest radio observations of the large galaxy M 31 in the constellation of Andromeda were made at Manchester, England, by Brown and Hazard (*1*) in 1951. They worked at 158 Mcy/sec. Since then, many groups have studied M 31. Among the most recent radio maps are the 408 Mcy/sec map made at Manchester by Large, Mathewson, and Haslam (*2*), who used a beam 40 minutes of arc by 56 minutes of arc to half power points, and the 1400 Mcy/sec map made at Ohio State by Kraus, who used a beam 11 minutes of arc by 40 minutes of arc.

These studies have shown that the radio emission from M 31 can be divided into two components, one called the disk component, which corresponds approximately with the visible galaxy, and the other a much larger component called the corona, which extends over 10 degrees along the major axis of the galaxy, and 6 degrees along the minor axis.

During the period November 1963 to January 1964, the region of the sky which includes M 31 was surveyed with the University of Illinois 400-foot (122-meter) radio telescope. The circular beam is 16 minutes of arc between half power points at 610.5 Mcy/sec and

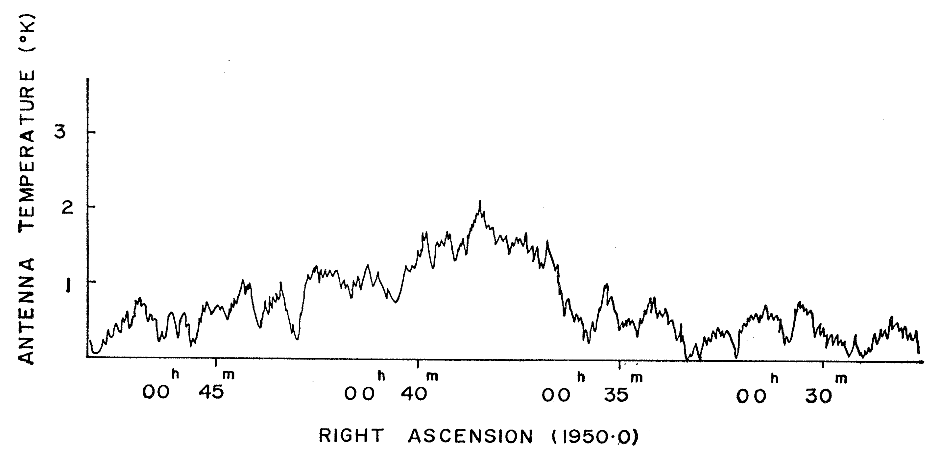

Fig. 1. A sample drift curve through M 31 at declination + 40°38′ (1950.0).