Table 1. Comparison of measurements for three girls and six adults (five women and one man).

Measurement	Children	Adults
Bone density measurements of phalanx 5-2		
Circle	0.72 ± 0.03	0.89 ± 0.08
Ellipse	0.77 ± 0.08	1.18 ± 0.11
Axes measurements (from trace)		
Diameter or *a*-axis (cm)		
finger	3.18 ± 0.09	3.81 ± 0.53
bone	1.38 ± 0.07	1.76 ± 0.27
b-axis (cm)		
finger	3.31 ± 0.07	3.59 ± 0.63
bone	1.02 ± 0.08	1.14 ± 0.17

The bone density value is expressed as x-ray equivalent grams of alloy per cubic centimeter of bone.

Certain approximations for in vivo determinations must be made, for example, the elimination of the effect of soft tissue. The wedge is made with a mass absorption characteristic similar to bone mineral but it cannot, also, absorb like flesh. Omnell (*1*) shows that mass absorption coefficients change with change in energy level and with substances of different atomic number. Rowland *et al.* (*2*), however, showed that most of the absorption by bone of x-rays with low energies (4 to 10 kv) is due to mineral components and that contributions due to soft tissues may be neglected. In the Tennessee studies the energy level (50 kv) is fairly low and the phalanx bone has only a small amount of tissue. Although a correction for surrounding tissue is made, one cannot be made for the soft tissue within the bone. The difference from bone to bone per cubic centimeter can be considered negligible or may warrant the use of the term, bone density *index* but not bone density *coefficient*.

The degree of approximation to the actual density value depends, in part, upon the extent of deviation from the assumed circular outline. With lateral and anterior-posterior views of the finger, the cross-sectional areas can be determined as ellipses with two measured axes rather than as circles with one.

In children, 7 to 8 years old, density values (Table 1) for phalanx 5-2 were essentially the same, whether calculated from circular or elliptical outlines, making one radiation exposure seem adequate.

For adults, the deviation of the phalanx outline from a circle is greater than in a child as shown by the *b*-axis measurements in Table 1. A greater deviation of the density value results. The precision desired must be weighed against the disadvantages of taking two x-ray pictures.

Bone densities of phalanx 5-2 in vitro (five men, 1.03 ± 0.09; five women, 0.93 ± 0.24) were obtained by Virtama *et al.* (*3*) from weight per volume measurements. Rowland *et al.* (*2*) expressed bone density for 22 subjects in terms of hydroxyapatite (1.19 ± 0.12) for the human femur in vitro. Considering unknown ages and nutritional histories, these values are in good agreement with the in vivo phalanx 5-2 values for adults (Table 1) and with previous findings of Williams and Samson (*4*) for Orientals (eight men, 1.00 ± 0.20; eight women, 1.08 ± 0.16) and Americans (eight men, 1.13 ± 0.27; eight women, 1.12 ± 0.21).

For useful bone density measurements, standard techniques and exact terminology must be observed. Work is continuing here to develop an instrument for greater precision and rapidity of measurement (*5*).

DOROTHY E. WILLIAMS
ROSSIE L. MASON
Tennessee Agricultural Experiment Station, Knoxville

References and Notes

1. K. Omnell, *Acta Radiol. Suppl.* **148**, 20, 22 (1957).
2. R. E. Rowland, J. Jowsey, J. H. Marshall, *Radiation Res.* **10**, 234 (1959).
3. P. Virtama, P. Kajanoja, V. K. Hopsu, A. Telkka, *Ann. Med. Exptl. Biol. Fennige Helsinki* **38**, 467 (1960).
4. D. E. Williams and A. Samson, *J. Am. Dietet. Assoc.* **36**, 462 (1960).
5. Grateful acknowledgment is made of the help from Dr. Isabel Tipton, Physics Department, University of Tennessee. This research was supported, in part, by grant A-3345 from the U.S. Public Health Service.

9 August 1962

Heart Autotransplantation: Effect on Myocardial Catecholamine and Histamine

Abstract. Complete excision and reimplantation of the canine heart is followed by a fall in myocardial norepinephrine to negligible levels. These decreases are attributable to the sympathetic denervation which necessarily accompanies the operative procedure. Myocardial histamine levels in survivors of this operation were not significantly different from those of normal dogs.

Complete excision and reimplantation of the dog's heart in its normal site is associated, in our hands, with an immediate mortality of 68 percent (*1*). In surviving animals we have observed certain alterations in cardiac function, presumably related to the complete extrinsic denervation which necessarily accompanies this procedure (*2*). Extrinsic sympathetic denervation should be associated with depletion of catecholamine stores in these hearts (*3*). Moreover, the possibility of histamine depletion has been raised by reports that denervation of other organs resulted in loss of tissue histamine. We now present the results of histamine and catecholamine assay in orthotopic autotransplanted canine myocardial tissues.

Table 1. Myocardial catecholamines and histamine in normal dogs and dogs after orthotopic cardiac autotransplantation.

Sample No.	Assay (μg/g)	
	Catecholamines	Histamines
	Normals	
C 4	0.88	2.15
C 7	0.80	3.28
C 9	0.72	2.27
C 11	0.88	4.10
C 12	0.73	7.04
C 14	0.45	5.50
C 16	1.00	5.80
C 18	0.84	6.50
Average	0.79 ± 0.16*	4.58 ± 1.90*
	Autotransplants	
TR 3	0.01	4.50
TR 5	0.05	3.60
TR 6	0.00	6.62
TR 11	0.00	4.62
TR 19	0.01	4.65
Average	0.01 ± 0.02*	4.80 ± 1.12*

* Standard deviation

The cardiac autotransplantation involves division and reanastomosis of the two venae cavae, the ascending aorta, and the main pulmonary artery. Temporary separation of the heart from the mediastinum with complete extrinsic denervation is completed by cutting the left atrium away from its posterior attachment and resuturing it in its original location.

Five dogs which survived the cardiac autotransplantation procedure were studied from 7 to 28 days after operation. Immediately after sacrifice of the animal, the heart was excised and frozen at the temperature of dry ice. The entire heart, including atria and ventricles, was minced and thoroughly mixed. Samples of the mixture were subsequently studied. Catecholamines were assayed fluorometrically by the method of Crout *et al.* (*4*). Oxidations were carried out at *p*H 4.9 in order to express results as norepinephrine equivalents. Tissue histamine was assayed fluorometrically by the method of Shore and his co-workers (*5*). Eight normal dogs of comparable size were sacrificed in a similar manner. Assay

of these hearts provided normal values for comparison.

The catecholamine content of reimplanted hearts averaged 0.01 μg/g. The catecholamine content of the normal dog hearts averaged 0.75 μg/g.

The histamine content of reimplanted hearts averaged 4.80 μg/g, and the histamine content of the normal dog hearts averaged 4.58 μg/g. Individual values for histamine and catecholamine content are presented in Table 1.

These data indicate that the autotransplanted canine heart is depleted of catecholamine but not of histamine. Our results, therefore, support the hypothesis of von Euler that the histamine content of an organ, unlike the norepinephrine content, is not dependent upon the presence of sympathetic nerves (*6*).

The autotransplant provides a preparation which is important in homotransplantation studies. One may analyze changes in chemical composition and in pharmacological responsiveness of the organ graft without the changes superimposed by immunologic rejection. Moreover, an autotransplant provides assurance of total extrinsic denervation restricted to the heart. Such a denervated autotransplant maintains the animal's life, whereas the heterotopic cardiac homograft shows electrical and mechanical activity but is incapable of supporting life.

Our studies support the hypothesis of Wegmann (*7*) that a puppy heart transplanted to another dog's neck is depleted of catecholamines by virtue of denervation rather than by an immunologic phenomenon (*8*).

THEODORE COOPER,
VALLEE L. WILLMAN,
MAX JELLINEK, C. ROLLINS HANLON
Department of Surgery and
Center for Cardiovascular Research, St. Louis University School of Medicine, St. Louis, Missouri

References and Notes

1. V. L. Willman, T. Cooper, L. G. Cian, C. R. Hanlon, *Surg. Gynecol. Obstet.*, in press.
2. ———, *Surgical Forum* **115**, 229 (1962).
3. T. Cooper, J. W. Gilbert, Jr., R. D. Bloodwell, J. R. Crout, *Circulation Res.* **9**, 275 (1961).
4. J. R. Crout, C. R. Creveling, S. Udenfriend, *J. Pharmacol. Exptl. Therap.* **132**, 269 (1961).
5. P. A. Shore, A. Burkhalter, V. H. Cohn, Jr., *ibid.* **127**, 182 (1959).
6. U. S. von Euler, in *Histamine*, Ciba Foundation Symposium (Little, Brown, Boston, 1956), p. 235.
7. A. Wegmann, C. Chiba, A. Chrysohou, R. J. Bing, *Proc. Soc. Exptl. Biol. Med.* **109**, 543 (1962).
8. This work was supported by grants H-6762 and H-6312 from the U.S. Public Health Service.

6 July 1962

Uptake of Strontium-85 by Alfalfa

Abstract. Experiments with alfalfa were carried out to study the possibility of changes with time in the availability of radiostrontium in soil. After the soil was treated once with Sr^{85}, the first crop was harvested after 60 days of growth. Four subsequent crops, cut at successive 4-week intervals, were examined. The difference in uptake between the second and fifth crops was statistically significant, suggesting that some fixation of Sr^{85} may occur in the soil. The effects of various applications of ammonium dihydrogen phosphate, monocalcium phosphate, calcium chloride, and potassium chloride on the uptake of Sr^{85} by alfalfa were also investigated. Of the experiments carried out, only the treatment with 1.0 meq of potassium per 100 g of soil resulted in a statistically significant reduction in strontium uptake.

In a study on changes with time in the availability of strontium-90 in soil, Squire (*1*) pointed out that such investigations are of importance in assessing the long-term consequences of the deposition of Sr^{90} on agricultural land. It is of interest to ascertain whether Sr^{90} could become progressively fixed in the soil and, therefore, less available to plants. The work of Morgan (*2*) showed that fallout Sr^{90} was not less available to ryegrass than freshly added Sr^{85}, thus indicating that the availability of Sr^{90} did not decrease appreciably with time. On the other hand, in studies with ryegrass planted on drums of soil whose surface had been treated with carrier-free Sr^{90}, Squire (*1*) noted that in four seasons there was a 20 to 30 percent decrease in the Sr/Ca ratio in the grass. It was suggested that this reduction may be attributable to either or both of two causes, namely, slow chemical changes that have reduced the availability of the Sr^{90} in the soil and the increasing penetration with time of the Sr^{90} down the soil profile. The effects of deeper penetration may be of considerable importance; Milbourn (*3*), after ploughing the soil to a depth of 11 inches instead of leaving its surface contaminated, has reported that the absorption of radiostrontium by the shallow-rooted ryegrass could be reduced by a factor of 4.

As an attempt to study further the possibility of changes with time in the availability of radiostrontium in soil, experiments with alfalfa were carried out because successive crops of the above-ground portion of the plant can be harvested at different time intervals. In addition, the effects of a number of chemical nutrients on the uptake of radiostrontium were investigated. Plants of the Grimm variety were grown, one per pot, in the greenhouse. Each pot contained 400 g of Saskatchewan Oxbow loam soil which had a *p*H of 7.2, and 19.2, 6.5, 1.9, and 0.1 meq of exchangeable Ca, Mg, K, and Na, respectively, per 100 g of soil. Before seeding, each pot of soil (except in one series) was first mixed thoroughly with 50 ml of solution containing approximately 0.1 mc of carrier-free Sr^{85}. In the single exception, the Sr^{85} solution was added to the surface of the soil without mixing. In the studies with chemical nutrients, each pot of soil was also mixed with 50 ml of solution containing various levels of ammonium dihydrogen phosphate, monocalcium phosphate, calcium chloride, or potassium chloride, or with 50 ml of distilled water as a control. During the entire period of the experiments, daily watering maintained soil moisture at its field capacity. After 60 days of growth, the first crop was harvested. The entire above-ground portion of each plant was analyzed for Sr^{85} uptake. Four more successive crops were cut at 4-week intervals, and each cutting was assayed for radioactivity (*4*). The results are summarized in Tables 1 and 2 (*5*).

From Table 1, it may be noted that

Table 1. Uptake of Sr^{85} by successive crops of alfalfa. Each value is the average of analyses of 36 plants.

Crop	Harvest date (days after germination)	Uptake (%) per gram of dried plant
1	60	1.65
2	88	1.35
3	116	1.29
4	144	1.28
5	172	1.20
Least significant difference		0.13*

* Significant at the 1-percent level.

Table 2. Uptake of Sr^{85} by alfalfa grown in soil with or without fertilizer treatment. Each value is the average of analyses of 20 plants.

Nutrient	Dosage (meq /100 g of soil)	Uptake (%) per gram of dried plant
None (surface application)		0.63*
None (control)		1.44
$NH_4H_2PO_4$	0.08 PO_4†	1.50
	0.8 PO_4	1.51
$Ca(H_2PO_4)_2$	0.08 PO_4, 0.03 Ca†	1.29
	0.8 PO_4, 0.3 Ca	1.33
$CaCl_2$	0.03 Ca	1.28
	0.3 Ca	1.37
KCl	1.0 K	1.13*
Least significant difference		0.17

* Significantly different from the control at the 1-percent level. † This dosage is equal to a treatment of about 60 lb of nutrient per acre of soil, assuming the weight of 1 acre of soil to be 2×10^6 lb.