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TRACE ELEMENTS IN HUMAN TISSUE

PART II. ADULT SUBJECTS FROM THE UNITED STATES

ISABEL H. TIPTON

Department of Physics, The University of Tennessee, Knoxville, Tennessee

and

M. J. COOK

Health Physics Division, Oak Ridge National Laboratory*, Oak Ridge, Tennessee

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Abstract—Central values and an estimate of the variation about the central values are given for 24 trace elements and the dry, and ash content of samples of 29 different tissues of 150 adult victims of instantaneous death who had spent their lives in the United States.

INTRODUCTION

IN THE program for spectrographic analysis of human tissue which has been in progress since 1951 at the University of Tennessee and the Health Physics Division of Oak Ridge National Laboratory, tissues from some 250 subjects from the United States have been analyzed. The methods of collection, sample preparation, and spectrographic and statistical analysis described in the first paper of this series[1] were followed for tissues of 173 of these subjects, tissues of the others having been collected, ashed and analyzed during the early developmental stage of the program. (Most of the subjects from the early group were not free from disease). One hundred and fifty of the group of 173 were adults (age >20). Since preliminary examination of the data indicated marked differences with age in the concentration of certain elements in certain tissues, the adults and the children have been treated as two separate groups for statistical study.

This paper gives central values and an estimate of the variation about the central values for 27 variables in 29 tissues of 150 adult subjects from the United States. This group is considered as a sample of the normal adult population of the United States and, as such, a source of information for "standard man". It will also serve as a basis of comparison, in later papers, for groups of different geographical origin and different ages.

In reporting the amounts of trace metals in biological materials different observers have used different bases of reference and different measures of central tendency. BUTT *et al.*,[2] TIETZ *et al.*[3] and HARDING-BARLOW[4] have reported values as concentrations in dry tissue. THIERS and VALLEE[5] have used nitrogen content as the reference in calculating concentrations in cell fractions, and they have also reported some values for perfused liver on the basis of wet weight. STITCH[6] and his co-workers report concentrations in dry ash and KOCH[7] and his co-workers concentrations in a modified dry ash. Values for concentration in the authors' preliminary reports[8] were based on wet tissue, and in the chapter in *Metal Binding in Medicine*[9] on dry ash. The use of different bases has made direct comparison between different laboratories difficult, especially since most authors have not reported the relations between the wet, dry and ash weights of their samples. In the present studies measurements of concentration were made, and are reported here, as μg/g in ash or as per cent in ash. In this report the concentration as μM/g of ash is also indicated in the figures since this provides a way of comparing the relative number of atoms of elements in tissues. The ash per cent of wet and the ash per cent of dry are also included so that values

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can be readily converted to the wet or dry basis.

As the central value and variation of a parameter, many observers report the mean and the standard error of the mean as a matter of course, assuming that in the population the individual values are normally distributed around the central value. As this paper shows, such an assumption is not justified for most trace elements in most tissues. HARDING-BARLOW[4] has demonstrated a log-normal distribution for a number of elements in nine tissues and has worked out a "most frequent concentration" based on the geometric mean. PERRY *et al.*[10] also found it appropriate to assume that the concentrations of Cd in kidney were log-normally distributed.

RESULTS

The data reported here were analyzed both by common statistical methods and by a distribution-free method involving ranking the values of the concentration of an element in a tissue.[1] For those elements which were observed above the lower limit of detection the mean and the standard deviation and standard error of the mean were calculated, and the 80 per cent range (10th–90th percentiles) the median, and the 95 per cent confidence interval of median[11] determined (Table 1). Since no exact value for the mean could be calculated for the elements which did not occur above the lower limit in every sample, the lower and upper limits of the range of the mean were calculated by assigning first zero, and then the detection limit, as values for all those samples in which the element was not observed. The average of these two extremes has been used when a single value for the mean was needed (as for instance in the calculations of upper limit for the population). For those elements for which a statistic lay below the limit of detection, the value is reported as "less than the lower limit".

A comparison of the median and mean values for concentrations of elements in tissues in Table 1 makes it apparent that for most elements in most tissues the distribution of values for concentration is not normal. The mean is nevertheless a good statistic for these data and it is "three times the mean" that the FRC[12] assumes to be the upper limit of the variation in the population. In analysis of independence and of variance for skewed data, however, the median is a better estimate of central tendency, and, according to KENDALL and STUART[13] the use of the mean and the standard deviation in these calculations leads to erroneous conclusions.

In Figure 1, a distinction has been made between the elements potassium (Fig. 1(v)) and phosphorus (Fig. 1(u)) which do show a normal distribution, and the other elements which do not. For potassium and phosphorus, the mean plus and minus twice the standard error of the mean are represented by the central line and two ends of the bar. For all other elements (Fig. 1(a) through 1(t) and for the per cent ash of wet (Fig. 1(w)) and per cent ash of dry (Fig. 1(x)), the central vertical line represents the median, the bar the 80 per cent range, and the dotted horizontal line the total range. The lower limit of detection is indicated where pertinent and possible on the scale by a vertical line. Concentrations in μM/g of ash may be read from the top scale. The numbers following the name of a tissue indicate the number of samples out of the total number analyzed in which the element was observed above the limit of detection. This ratio is repeated in the tables.

DISCUSSION

Trace metals can be divided into two groups, the essential, for which a physiological function is known, and the non-essential, for which no function has yet been discovered. Obviously the line of demarcation between the two is not sharp and elements which are called non-essential today may be shown tomorrow to serve some useful function. The known essential elements are, in general, more nearly ubiquitous and less variable than the so-called non-essential.[14] Especially is this true in the case of those elements for which specific mechanisms to control the concentration are known. Even an essential element which occurs in a tissue in widely varying amounts, however, such as calcium in aorta, behaves to that extent like a "non-essential" element. Also, by the criteria of ubiquity and constancy, cobalt and perhaps molybdenum, both of which are known

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Table 1. Concentrations of elements in tissues. (Minus sign should be read as "less than" throughout).

Adrenal	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	15/15	0.20	0.80	0.46	0.30	0.70	0.50	0.26	0.07		
Ash % of dry	9/15	0.1	2.5	1.1	0.2	1.6	1.0	0.76	0.25		
G per 100 g of tissue ash											
Calcium	10/10	0.42	2.0	0.76	0.54	1.2	0.93	0.50	0.16		
Iron	10/10	0.36	1.6	0.65	0.46	1.1	0.75	0.39	0.12		
Magnesium	10/10	0.46	1.5	0.84	0.62	1.1	0.89	0.31	0.10		
Phosphorus	8/8	11	20	16	11	20	16	2.7	0.9		
Potassium	8/8	14	19	17	14	19	17	1.9	0.6		
μg per g of tissue ash											
Aluminum	13/13	62	450	180	120	350	480	1100	290		
Copper	12/12	160	250	200	160	230	210	53	15		
Manganese	13/13	24	49	32	29	46	36	11	3.1		
Strontium	13/13	0.8	9.5	3.5	1.3	9.0	4.5	3.7	1.0		
Zinc	15/15	1300	2000	1600	1400	1900	1600	270	70		
Barium	13/13	1.2	12	6.0	1.4	11	32	96	27	2	3
Bismuth	2/15	−2	5	−2	−2	−2				19	23
Boron	10/15	−10	71	10	−10	17				66	79
Cadmium	11/15	−50	150	50	−50	100					
Chromium	13/13	2.0	16	9.4	4.0	13	10	9.6	2.7	4	5
Cobalt	6/14	−2	11	−2	−2	10				15	21
Gold	6/15	−10	60	−10	−10	10					
Lead	15/15	11	140	27	13	52	53	64	16	14	15
Molybdenum	10/13	−4	22	15	−4	21				29	30
Nickel	10/13	−5	60	10	−5	34				1.3	1.3
Silver	10/13	−0.1	3.2	0.8	−0.1	2.0				28	28
Tin	14/15	5	72	23	5	40				18	20
Titanium	8/13	−5	45	15	−5	45				0	1
Vanadium	1/13	−1	−1	−1	−1	−1					

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Table 1 (*Continued*) (*Minus sign should be read as "less than" throughout*).

Aorta	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	101/105	0.90	3.1	1.4	1.3	1.5	1.7	1.3	0.13		
Ash % of dry	97/105	2.4	10	3.8	3.6	4.2	5.1	3.7	0.38		
G per 100 g of tissue ash											
Calcium	94/94	2.8	8.0	5.5	5.0	6.0	5.4	2.3	0.24		
Iron	93/93	0.15	0.60	0.27	0.23	0.33	0.33	0.21	0.02		
Magnesium	94/94	0.94	2.0	1.4	1.3	1.5	1.5	0.61	0.06		
Phosphorus	91/91	5	9	7	6	7	6	1.9	0.2		
Potassium	91/91	4	14	9	8	10	9.3	4.8	0.5		
μg per g of tissue ash											
Aluminum	104/104	11	140	29	23	39	57	65	6.4		
Copper	103/103	50	140	90	84	100	97	47	4.6		
Manganese	95/95	4	17	8	7	9	11	12	1.2		
Strontium	103/103	15	78	33	27	38	41	30	2.9		
Zinc	104/104	1100	2700	1800	1600	2000	1900	720	70		
Barium	103/105	2.5	17	7.0	6.4	8.0				9.0	9.0
Bismuth	19/105	−2	11	−2	−2	−2				9	11
Boron	3/105	−10	−10	−10	−10	−10				0	10
Cadmium	19/105	−50	60	−50	−50	−50				14	55
Chromium	90/103	−0.1	10	2.0	0.6	3.0				4.4	4.5
Cobalt	21/104	−2	6	−2	−2	−2				2	4
Gold	27/105	−10	40	−10	−10	−10				12	19
Lead	104/104	34	280	140	120	170	160	100	10		
Molybdenum	3/104	−4	−4	−4	−4	−4				0	4
Nickel	47/104	−5	20	−5	−5	5				7	10
Silver	63/105	−0.1	1.0	0.1	0.1	0.1				0.6	0.7
Tin	96/105	5	38	14	11	18				24	25
Titanium	45/104	−5	25	−5	−5	5				8	12
Vanadium	0/104	−1	−1	−1	−1	−1				0	1

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Table 1 (Continued) (Minus sign should be read as "less than" throughout)

Brain	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	126/129	1.4	2.0	1.5	1.5	1.6	1.7	0.49	0.04		
Ash % of dry	110/129	3.9	9.2	6.1	5.7	6.5	6.4	2.6	0.25		
G per 100 g of tissue ash											
Calcium	108/108	0.33	0.96	0.52	0.49	0.57	0.59	0.25	0.02		
Iron	108/108	0.22	0.48	0.32	0.30	0.35	0.34	0.10	0.01		
Magnesium	108/108	0.58	1.2	0.90	0.84	0.96	0.92	0.25	0.02		
Phosphorus	102/102	16	26	20	20	21	20	4.3	0.4		
Potassium	102/102	13	25	19	17	20	19	4.9	0.4		
μg per g of tissue ash											
Aluminum	127/127	6	38	15	12	17	22	47	4.2		
Copper	127/127	240	500	360	340	380	370	130	12		
Manganese	127/127	10	32	18	16	20	20	8.2	0.7		
Strontium	127/127	0.5	4.3	1.4	1.2	1.9	2.3	2.6	0.23		
Zinc	129/129	520	1100	760	700	820	820	380	34		
Barium	66/129	−0.2	1.8	0.2	−0.2	0.3				0.6	0.7
Bismuth	3/129	−2	−2	−2	−2	−2				0	2
Boron	17/129	−10	10	−10	−10	−10				1	10
Cadmium	0/129	−50	−50	−50	−50	−50				0	50
Chromium	84/128	−0.1	2.0	0.2	0.1	0.4				0.7	0.8
Cobalt	2/129	−2	−2	−2	−2	−2				0	2
Gold	1/129	−10	−10	−10	−10	−10				0	10
Lead	89/129	−5	39	5	5	10				19	21
Molybdenum	3/129	−4	−4	−4	−4	−4				0	4
Nickel	9/129	−5	−5	−5	−5	−5				3	8
Silver	113/128	−0.1	1.6	0.6	0.5	0.8				1.1	1.2
Tin	7/129	−5	−5	−5	−5	−5				1	6
Titanium	12/129	−5	−5	−5	−5	−5				0	5
Vanadium	0/129	−1	−1	−1	−1	−1				0	1

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Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Diaphragm	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	91/91	0.80	1.2	0.96	0.90	1.0	0.98	0.22	0.02		
Ash % of dry	91/91	2.4	4.2	3.4	3.2	3.6	3.4	0.71	0.07		
G per 100 g of tissue ash											
Calcium	91/91	0.30	0.94	0.58	0.50	0.62	0.61	0.29	0.03		
Iron	91/91	0.31	0.60	0.44	0.42	0.48	0.48	0.24	0.03		
Magnesium	91/91	1.2	2.5	1.7	1.5	1.8	1.7	0.52	0.05		
Phosphorus	89/89	10	16	13	12	14	13	2.5	0.2		
Potassium	89/89	16	30	23	21	24	23	5.3	0.5		
μg per g of tissue ash											
Aluminum	91/91	13	94	26	22	38	56	93	9.8		
Copper	91/91	110	200	140	130	150	150	41	4.2		
Manganese	91/91	6	32	15	12	18	17	12	1.2		
Strontium	91/91	1.4	7.8	3.3	2.9	3.7	4.5	4.3	0.45		
Zinc	91/91	3300	7200	4600	4200	5000	5000	1700	170		
Barium	76/91	0.2	4.2	1.8	1.5	2.2				2.5	2.5
Bismuth	5/91	−2	−2	−2	−2	−2				7	9
Boron	4/91	−10	−10	−10	−10	−10				0	10
Cadmium	6/91	−50	−50	−50	−50	−50				4	51
Chromium	90/91	0.4	6.4	2.3	1.6	3.0				3.7	3.7
Cobalt	5/91	−2	−2	−2	−2	−2				3	5
Gold	9/91	−10	−10	−10	−10	−10				1	11
Lead	75/91	−5	29	10	7	11				14	15
Molybdenum	3/91	−4	−4	−4	−4	−4				0	4
Nickel	28/91	−5	19	−5	−5	−5				7	11
Silver	17/91	−0.1	0.5	−0.1	−0.1	−0.1				1.8	1.9
Tin	55/91	−5	29	5	−5	10				16	18
Titanium	33/91	−5	14	−5	−5	−5				5	8
Vanadium	0/91	−1	−1	−1	−1	−1				0	1

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Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Esophagus	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	67/68	0.50	1.1	0.90	0.90	0.99	0.89	0.21	0.03		
Ash % of dry	63/68	2.1	5.2	3.8	3.6	4.2	3.7	1.2	0.15		
G per 100 g of tissue ash											
Calcium	57/57	0.70	1.8	1.1	1.0	1.2	1.2	0.39	0.05		
Iron	57/57	0.19	0.86	0.40	0.35	0.49	0.47	0.25	0.03		
Magnesium	57/57	1.0	2.0	1.4	1.3	1.5	1.4	0.47	0.06		
Phosphorus	55/55	7	12	9	9	10	9	1.7	0.2		
Potassium	55/55	14	25	18	16	19	19	4.4	0.6		
μg per g of tissue ash											
Aluminum	66/66	25	180	61	47	86	99	120	14		
Copper	66/66	84	200	120	110	140	140	84	10		
Manganese	66/66	6	40	13	10	16	17	12	1.5		
Strontium	65/65	4.3	17	8.2	6.5	10	9.6	5.6	0.69		
Zinc	67/67	1900	4500	2600	2300	2800	3000	1400	170		
Barium	66/66	0.6	12	3.0	2.5	4.0	8.1	22	2.7		
Bismuth	6/68	−2	−2	−2	−2	−2				25	26
Boron	7/68	−10	10	−10	−10	−10				5	15
Cadmium	4/68	−50	−50	−50	−50	−50				3	51
Chromium	63/66	0.8	11	3.0	1.9	4.7				5.1	5.1
Cobalt	5/67	−2	−2	−2	−2	−2				0	2
Gold	18/68	−10	22	−10	−10	−10				5	13
Lead	55/68	−5	70	10	5	15				34	34
Molybdenum	1/66	−4	−4	−4	−4	−4				0	4
Nickel	27/66	−5	22	−5	−5	5				8	12
Silver	32/68	−0.1	1.0	−0.1	−0.1	0.1				0.3	0.3
Tin	58/68	−5	62	18	14	25				50	51
Titanium	32/66	−5	44	−5	−5	7				13	16
Vanadium	5/66	−1	−1	−1	−1	−1				0	1

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Table 1 (Continued) (Minus sign should be read as "less than" throughout)

Heart	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	137/140	0.90	1.2	1.1	1.0	1.1	1.1	0.17	0.01		
Ash % of dry	121/140	3.0	5.0	4.0	3.9	4.3	4.1	0.88	0.08		
G per 100 g of tissue ash											
Calcium	120/120	0.21	0.80	0.38	0.33	0.42	0.44	0.24	0.02		
Iron	123/123	0.34	0.70	0.47	0.45	0.49	0.50	0.16	0.01		
Magnesium	122/122	1.1	2.3	1.6	1.5	1.7	1.7	0.51	0.05		
Phosphorus	115/115	13	19	15	15	16	16	2.3	0.2		
Potassium	115/115	17	28	23	22	24	23	4.4	0.4		
μg per g of tissue ash											
Aluminum	140/140	10	70	20	17	24	35	44	3.7		
Copper	140/140	250	460	350	320	370	350	89	7.5		
Manganese	139/139	12	40	20	19	23	23	11	0.9		
Strontium	140/140	1.1	7.1	2.6	2.3	3.2	3.5	2.8	0.24		
Zinc	140/140	2000	3700	2700	2500	2800	2800	790	67		
Barium	93/140	−0.2	3.1	0.7	0.3	1.2				1.2	1.3
Bismuth	6/140	−2	−2	−2	−2	−2				0	2
Boron	11/140	−10	−10	−10	−10	−10				1	10
Cadmium	3/140	−50	−50	−50	−50	−50				1	50
Chromium	125/140	−0.1	8.2	1.5	1.0	2.1				3.4	3.4
Cobalt	39/140	−2	5	−2	−2	−2				2	3
Gold	6/140	−10	−10	−10	−10	−10				0	10
Lead	79/140	−5	18	5	−5	5				9	11
Molybdenum	8/140	−4	−4	−4	−4	−4				0	4
Nickel	48/140	−5	27	−5	−5	−5				7	11
Silver	31/138	0.1	0.5	−0.1	−0.1	−0.1				0.5	0.6
Tin	84/140	−5	27	5	5	10				13	15
Titanium	24/140	−5	5	−5	−5	−5				2	6
Vanadium	0/140	−1	−1	−1	−1	−1				0	1

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Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Intestine, duodenum	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	64/68	0.60	1.0	0.80	0.80	0.90	0.81	0.16	0.02		
Ash % of dry	60/68	2.4	5.0	3.9	3.6	4.1	3.8	1.0	0.13		
G per 100 g of tissue ash											
Calcium	60/60	0.53	1.7	0.83	0.70	0.98	1.0	0.74	0.09		
Iron	60/60	0.24	0.78	0.45	0.40	0.59	0.50	0.22	0.03		
Magnesium	60/60	0.85	1.7	1.3	1.2	1.4	1.3	0.31	0.04		
Phosphorus	57/57	11	19	15	14	16	15	3.5	0.4		
Potassium	57/57	13	23	18	17	19	18	3.8	0.5		
μg per g of tissue ash											
Aluminum	67/67	18	260	43	35	58	120	230	28		
Copper	67/67	160	420	260	240	290	300	160	20		
Manganese	67/67	25	100	57	50	68	70	83	10		
Strontium	67/67	2.4	25	11	7.4	14	13	9.6	1.2		
Zinc	68/68	1700	3400	2400	2200	2600	2500	610	74		
Barium	65/67	1.2	8.4	3.7	3.3	4.1				6.2	6.2
Bismuth	8/68	−2	9	−2	−2	−2				26	28
Boron	16/68	−10	14	−10	−10	−10				3	11
Cadmium	38/68	−50	85	50	−50	50				44	66
Chromium	63/67	0.4	6.4	2.3	1.5	2.9				3.4	3.4
Cobalt	6/67	−2	−2	−2	−2	−2				1	3
Gold	13/68	−10	20	−10	−10	−10				3	12
Lead	67/68	5	82	25	18	34				41	41
Molybdenum	6/67	−4	−4	−4	−4	−4				1	4
Nickel	35/67	−5	16	5	−5	9				6	9
Silver	35/68	−0.1	1.1	0.1	−0.1	0.1				0.5	0.6
Tin	61/68	−5	160	28	21	35				61	62
Titanium	25/67	−5	23	−5	−5	−5				5	8
Vanadium	5/67	−1	−1	−1	−1	−1				0	1

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Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Intestine, jejunum	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	102/104	0.60	1.1	0.90	0.80	0.90	0.92	0.30	0.03		
Ash % of dry	89/104	3.0	5.3	3.9	3.7	4.2	4.0	1.1	0.12		
G per 100 g of tissue ash											
Calcium	83/83	0.48	1.4	0.82	0.70	0.90	0.87	0.38	0.04		
Iron	84/84	0.20	0.68	0.31	0.28	0.37	0.41	0.30	0.03		
Magnesium	83/83	0.92	2.1	1.2	1.1	1.3	1.3	0.57	0.06		
Phosphorus	80/80	12	22	17	16	18	17	3.9	0.4		
Potassium	79/79	13	23	19	17	19	18	3.6	0.4		
μg per g of tissue ash											
Aluminum	101/101	18	150	37	33	48	71	93	9.2		
Copper	101/101	160	330	230	230	250	250	78	7.7		
Manganese	101/101	32	120	58	51	64	68	40	3.9		
Strontium	100/100	3.1	33	11	8.0	14	15	13	1.3		
Zinc	103/103	1600	3100	2200	2000	2300	2300	680	67		
Barium	99/101	0.9	8.4	4.0	3.0	4.5				4.4	4.4
Bismuth	16/104	−2	10	−2	−2	−2				26	28
Boron	26/104	−10	16	−10	−10	−10				4	12
Cadmium	60/104	−50	100	50	−50	60				64	85
Chromium	88/101	−0.1	6.4	1.7	1.2	2.1				4.1	4.1
Cobalt	7/102	−2	−2	−2	−2	−2				4	6
Gold	19/104	−10	25	−10	−10	−10				5	13
Lead	97/104	5	53	13	10	16				28	29
Molybdenum	7/102	−4	−4	−4	−4	−4				0	4
Nickel	31/102	−5	11	−5	−5	−5				3	7
Silver	53/104	−0.1	1.8	0.1	−0.1	0.1				0.5	0.5
Tin	100/104	8	110	36	28	45				73	73
Titanium	15/102	−5	5	−5	−5	−5				2	6
Vanadium	4/102	−1	−1	−1	−1	−1				0	1

1133646

Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Intestine, ileum	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	83/85	0.40	1.1	0.76	0.70	0.80	0.75	0.30	0.03		
Ash % of dry	78/85	1.5	5.3	3.4	2.9	3.7	3.4	1.7	0.19		
G per 100 g of tissue ash											
Calcium	77/77	0.74	2.8	1.4	1.2	1.7	1.6	0.98	0.11		
Iron	78/78	0.18	0.61	0.32	0.28	0.36	0.36	0.17	0.02		
Magnesium	77/77	1.1	3.8	1.8	1.6	2.0	2.1	1.1	0.12		
Phosphorus	75/75	10	17	13	12	14	14	3.2	0.3		
Potassium	75/75	9	22	16	15	18	16	4.7	0.5		
μg per g of tissue ash											
Aluminum	82/82	25	220	86	60	110	290	1600	180		
Copper	84/84	170	400	240	220	270	280	130	14		
Manganese	84/84	33	200	74	68	90	110	110	11		
Strontium	81/81	6.0	62	25	19	30	32	37	4.1		
Zinc	84/84	1700	4900	2800	2400	3100	3200	2100	230		
Barium	84/84	3.8	28	9.2	8.0	10	12	9.3	1.0	6	8
Bismuth	12/84	−2	9	−2	−2	−2				3	12
Boron	16/84	−10	10	−10	−10	−10				16	53
Cadmium	21/84	−50	60	−50	−50	−50				6.6	6.6
Chromium	80/84	0.5	12	4.0	2.7	5.5				5	6
Cobalt	18/83	−2	10	−2	−2	−2				8	16
Gold	21/84	−10	33	−10	−10	−10				33	33
Lead	82/84	5	62	20	16	27				3	6
Molybdenum	18/83	−4	9	−4	−4	−4				20	22
Nickel	52/84	−5	44	9	5	16				0.4	0.4
Silver	49/84	−0.1	1.1	0.1	0.1	0.3				160	160
Tin	80/84	15	430	79	51	130				6	9
Titanium	36/84	−5	21	−5	−5	5				1	1
Vanadium	31/84	−1	3	−1	−1	−1					

1133647

Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Intestine, cecum	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	31/31	0.40	0.90	0.60	0.50	0.70	0.67	0.25	0.04		
Ash % of dry	31/31	1.3	3.2	2.0	1.6	2.8	2.3	1.0	0.18		
G per 100 g of tissue ash											
Calcium	31/31	1.1	4.6	2.4	1.5	3.1	2.5	1.4	0.25		
Iron	31/31	0.18	0.52	0.32	0.29	0.41	0.37	0.17	0.03		
Magnesium	31/31	1.6	5.0	2.7	2.1	3.9	3.1	1.4	0.25		
Phosphorus	31/31	7	13	11	10	12	11	2.7	0.4		
Potassium	31/31	9	22	16	13	18	16	5.0	0.9		
μg per g of tissue ash											
Aluminum	31/31	24	780	130	69	170	280	420	76		
Copper	31/31	150	280	220	180	250	220	64	11		
Manganese	31/31	24	400	110	74	200	180	170	31		
Strontium	31/31	11	100	42	30	52	52	49	8.9		
Zinc	31/31	1900	4400	3500	2800	4100	3300	1000	180		
Barium	31/31	5.4	31	18	9.0	25	18	12	2.1		
Bismuth	8/31	−2	43	−2	−2	−2				15	17
Boron	3/31	−10	−10	−10	−10	−10				2	11
Cadmium	5/31	−50	50	−50	−50	−50				10	52
Chromium	31/31	1.7	20	6.2	3.4	8.0	7.3	6.1	1.1		
Cobalt	10/31	−2	8	−2	−2	2				37	39
Gold	6/31	−10	20	−10	−10	−10				5	13
Lead	31/31	5	90	27	21	41	38	36	6.4		
Molybdenum	6/31	−4	5	−4	−4	−4				1	4
Nickel	29/31	5	100	21	14	30				34	34
Silver	16/31	−0.1	1.4	0.1	−0.1	0.8				1.0	1.1
Tin	31/31	45	800	130	60	280	330	430	78		
Titanium	16/31	−5	11	5	−5	8				5	8
Vanadium	14/31	−1	4	−1	−1	2				1	2

1133648

Table 1 (Continued) (Minus sign should be read as "less than" throughout)

Intestine, sigmoid colon	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	107/109	0.40	1.0	0.70	0.60	0.70	0.68	0.27	0.03		
Ash % of dry	90/109	0.9	4.2	2.5	2.0	2.9	2.6	1.3	0.14		
G per 100 g of tissue ash											
Calcium	88/88	0.64	3.3	1.4	1.2	1.7	1.7	1.1	0.11		
Iron	88/88	0.18	0.52	0.30	0.25	0.34	0.34	0.18	0.02		
Magnesium	88/88	1.3	4.5	2.0	1.7	2.4	2.6	2.0	0.22		
Phosphorus	84/84	9	14	12	11	13	12	3.1	0.3		
Potassium	82/82	13	24	18	17	19	18	4.7	0.5		
μg per g of tissue ash											
Aluminum	107/107	23	340	82	65	120	160	230	22		
Copper	108/108	150	340	210	190	230	230	81	7.8		
Manganese	107/107	16	150	46	32	64	76	100	9.7		
Strontium	107/107	5.5	76	23	18	28	33	29	2.8		
Zinc	108/108	1800	4000	2600	2400	2700	2700	820	79		
Barium	108/108	1.7	38	6.1	4.5	8.0	14	24	2.3	4	6
Bismuth	14/109	−2	5	−2	−2	−2				3	11
Boron	17/109	−10	10	−10	−10	−10				14	52
Cadmium	25/109	−50	60	−50	−50	−50				6.5	6.5
Chromium	101/108	0.5	16	3.9	3.2	5.2				22	24
Cobalt	21/108	−2	11	−2	−2	−2				5	13
Gold	19/109	−10	25	−10	−10	−10				25	26
Lead	94/109	−5	50	13	10	17				0	4
Molybdenum	4/108	−4	−4	−4	−4	−4				26	28
Nickel	81/108	−5	55	12	10	20				0.7	0.7
Silver	64/109	−0.1	2.0	0.1	−0.1	0.1				100	100
Tin	107/109	10	330	45	34	56				8	12
Titanium	36/108	−5	33	−5	−5	−5				1	2
Vanadium	17/108	−1	3	−1	−1	−1					

1133649

Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Intestine, rectum	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	42/42	0.50	1.3	0.70	0.70	0.80	0.85	0.54	0.08		
Ash % of dry	41/42	1.2	5.2	3.1	2.6	3.2	3.3	2.5	0.38		
G per 100 g of tissue ash											
Calcium	41/41	0.94	3.5	1.7	1.5	2.2	2.0	0.98	0.15		
Iron	41/41	0.14	0.62	0.32	0.27	0.40	0.38	0.30	0.05		
Magnesium	41/41	1.4	3.7	2.3	2.0	2.7	2.6	1.2	0.19		
Phosphorus	41/41	8	13	10	9	11	10	2.0	0.3		
Potassium	41/41	14	25	19	17	20	19	5.6	0.8		
μg per g of tissue ash											
Aluminum	42/42	18	200	73	53	100	110	180	28		
Copper	42/42	110	270	170	150	190	180	58	9.0		
Manganese	42/42	11	180	39	29	61	82	130	19		
Strontium	42/42	5.2	57	26	20	32	28	19	2.9		
Zinc	42/42	2400	4800	3300	2900	3800	3500	1100	180		
Barium	41/42	2.0	37	7.2	4.9	10				15	15
Bismuth	6/42	−2	11	−2	−2	−2				7	8
Boron	8/42	−10	13	−10	−10	−10				3	11
Cadmium	5/42	−50	50	−50	−50	−50				6	51
Chromium	42/42	1.1	13	4.1	2.8	5.2	5.4	4.9	0.75		
Cobalt	10/42	−2	11	−2	−2	−2				5	6
Gold	3/42	−10	−10	−10	−10	−10				1	11
Lead	41/42	5	77	20	15	26				59	59
Molybdenum	2/42	−4	−4	−4	−4	−4				0	4
Nickel	38/42	5	38	16	11	20				23	23
Silver	14/42	−0.1	1.4	−0.1	−0.1	−0.1				0.6	0.6
Tin	39/42	5	180	57	30	95				130	130
Titanium	22/42	−5	16	5	−5	10				8	11
Vanadium	11/42	−1	2	−1	−1	−1				0	1

1133650

Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Kidney	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	142/145	0.99	1.3	1.1	1.1	1.1	1.1	0.20	0.02		
Ash % of dry	124/145	3.5	5.9	4.6	4.4	4.8	4.7	1.1	0.09		
G per 100 g of tissue ash											
Calcium	121/121	0.52	1.6	0.85	0.76	0.94	0.98	0.53	0.05		
Iron	123/123	0.40	1.1	0.64	0.59	0.72	0.69	0.28	0.02		
Magnesium	121/121	0.88	1.7	1.2	1.2	1.3	1.2	0.35	0.03		
Phosphorus	116/116	12	18	15	14	15	15	2.8	0.2		
Potassium	114/114	13	21	17	16	17	17	3.6	0.3		
μg per g of tissue ash											
Aluminum	141/141	14	82	25	21	28	43	68	5.7		
Copper	143/143	190	340	260	240	270	270	77	6.4		
Manganese	143/143	45	150	82	76	88	91	47	4.0		
Strontium	143/143	2.8	12	5.2	4.9	5.6	6.5	4.2	0.35		
Zinc	145/145	3200	7400	4500	4300	4800	4900	1700	140		
Barium	121/142	−0.2	4.0	1.3	1.0	1.6				2.2	2.3
Bismuth	42/145	−2	43	−2	−2	−2				24	26
Boron	20/145	−10	10	−10	−10	−10				2	11
Cadmium	145/145	1500	5100	2900	2600	3300	3200	1500	120		
Chromium	117/142	−0.1	4.5	1.0	0.7	1.6				2.2	2.2
Cobalt	21/144	−2	2	−2	−2	−2				4	5
Gold	15/145	−10	10	−10	−10	−10				2	11
Lead	145/145	42	220	98	88	110	120	87	7.2		
Molybdenum	140/144	20	48	31	29	33				33	33
Nickel	30/144	−5	11	−5	−5	−5				3	7
Silver	67/143	−0.1	1.0	−0.1	−0.1	0.1				0.3	0.3
Tin	140/145	5	46	16	14	21				24	24
Titanium	22/144	−5	5	−5	−5	−5				2	6
Vanadium	0/144	−1	−1	−1	−1	−1				0	1

1133651

Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Larynx	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	50/50	1.4	5.6	3.0	2.5	3.9	3.3	1.6	0.22		
Ash % of dry	49/50	4.3	16	9.3	7.5	10.9	9.3	4.0	0.57		
G per 100 g of tissue ash											
Calcium	49/49	2.6	10.0	7.0	6.2	7.6	6.8	2.7	0.39		
Iron	49/49	0.05	0.21	0.11	0.10	0.11	0.13	0.08	0.01		
Magnesium	49/49	0.71	1.8	1.1	1.1	1.2	1.2	0.42	0.06		
Phosphorus	49/49	4	8	7	6	7	6	1.4	0.2		
Potassium	48/48	2	11	5	3	8	6	3.3	0.4		
μg per g of tissue ash											
Aluminum	50/50	6	51	14	11	19	24	30	4.2		
Copper	50/50	14	150	33	25	48	59	66	9.4		
Manganese	35/35	2	18	6	4	10	8	6.4	1.1		
Strontium	50/50	10	70	25	20	27	32	26	3.7		
Zinc	48/48	680	2300	1200	960	1300	1300	600	87		
Barium	50/50	2.4	13	5.3	4.5	6.4	6.6	4.9	0.69	5	7
Bismuth	3/50	−2	−2	−2	−2	−2				1	11
Boron	4/50	−10	−10	−10	−10	−10				1	50
Cadmium	1/50	−50	−50	−50	−50	−50				2.1	2.1
Chromium	27/49	−0.1	6.0	0.1	−0.1	0.2				0	2
Cobalt	3/50	−2	−2	−2	−2	−2				0	10
Gold	3/50	−10	−10	−10	−10	−10					
Lead	50/50	11	140	64	43	84	94	160	22	0	4
Molybdenum	1/50	−4	−4	−4	−4	−4				5	9
Nickel	18/50	−5	17	−5	−5	5				0.2	0.3
Silver	20/50	−0.1	0.5	−0.1	−0.1	0.1				7	8
Tin	34/50	−5	16	8	5	10				4	8
Titanium	11/50	−5	10	−5	−5	−5				0	1
Vanadium	0/50	−1	−1	−1	−1	−1					

1133652

Table 1 (*Continued*) (*Minus sign should be read as "less than" throughout*).

Liver	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	147/150	1.0	1.7	1.3	1.3	1.3	1.3	0.34	0.03		
Ash % of dry	128/150	1.9	5.0	3.7	3.4	3.8	3.7	1.3	0.12		
G per 100 g of tissue ash											
Calcium	126/126	0.22	0.70	0.38	0.35	0.44	0.49	0.54	0.05		
Iron	127/127	0.53	2.4	1.4	1.1	1.5	1.5	0.87	0.08		
Magnesium	126/126	0.83	1.8	1.3	1.2	1.4	1.3	0.41	0.04		
Phosphorus	118/118	15	25	20	19	21	20	4.2	0.3		
Potassium	116/116	14	25	20	19	21	20	5.1	0.4		
μg per g of tissue ash											
Aluminum	148/148	17	120	47	37	53	65	85	7.0		
Copper	148/148	320	1300	510	480	560	680	610	50		
Manganese	148/148	55	220	100	92	120	130	85	7.0		
Strontium	146/146	0.7	3.5	1.6	1.3	1.7	2.1	2.3	0.19		
Zinc	150/150	2200	5900	3500	3200	3800	3800	1400	110		
Barium	68/146	−0.2	2.1	−0.2	−0.2	0.2				0.7	0.8
Bismuth	21/150	−2	7	−2	−2	−2				4	6
Boron	37/150	−10	10	−10	−10	−10				3	11
Cadmium	146/150	60	340	180	160	190				200	210
Chromium	115/146	−0.1	3.7	0.7	0.3	1.3				1.5	1.6
Cobalt	63/149	−2	10	−2	−2	2				4	5
Gold	4/150	−10	−10	−10	−10	−10				0	10
Lead	150/150	60	250	130	120	150	150	110	8.9		
Molybdenum	147/147	32	140	75	68	84	81	46	3.8		
Nickel	27/148	−5	11	−5	−5	−5				2	6
Silver	139/148	0.1	3.2	0.8	0.7	1.0				1.3	1.3
Tin	144/150	5	74	23	19	28				33	33
Titanium	34/148	−5	16	−5	−5	−5				5	9
Vanadium	5/148	−1	−1	−1	−1	−1				0	1

1133653

Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Lung	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	139/142	0.98	1.3	1.1	1.1	1.1	1.1	0.28	0.02		
Ash % of dry	121/142	3.6	6.1	4.8	4.6	5.0	4.9	2.6	0.23		
G per 100 g of tissue ash											
Calcium	119/119	0.64	1.6	1.0	0.92	1.1	1.1	0.43	0.04		
Iron	120/120	1.1	5.2	2.7	2.3	3.0	2.9	1.6	0.15		
Magnesium	119/119	0.62	1.3	0.86	0.80	0.92	0.91	0.25	0.02		
Phosphorus	111/111	7	14	10	9	11	10	2.7	0.2		
Potassium	110/110	14	24	18	17	19	18	4.1	0.3		
μg per g of tissue ash											
Aluminum	141/141	780	>4000	2000	1600	2200	2500	2200	180		
Copper	141/141	92	180	120	120	130	130	35	2.9		
Manganese	141/141	8	43	17	15	20	24	23	2.0		
Strontium	141/141	4.5	17	8.2	7.6	9.4	9.8	6.1	0.52		
Zinc	141/141	880	1800	1300	1200	1400	1400	410	35		
Barium	139/140	4.1	40	14	12	18				20	20
Bismuth	6/141	−2	−2	−2	−2	−2				3	5
Boron	28/141	−10	10	−10	−10	−10				2	11
Cadmium	71/141	−50	100	−50	−50	50				44	69
Chromium	139/139	3.4	50	13	10	16	20	21	1.8		
Cobalt	26/141	−2	9	−2	−2	−2				3	5
Gold	3/141	−10	−10	−10	−10	−10				0	10
Lead	141/141	15	140	47	40	55	67	69	5.8		
Molybdenum	5/141	−4	−4	−4	−4	−4				0	4
Nickel	70/141	−5	28	−5	−5	5				18	21
Silver	54/139	−0.1	0.5	−0.1	−0.1	−0.1				0.2	0.3
Tin	137/140	11	110	37	26	45				66	66
Titanium	139/141	55	700	220	180	250				380	380
Vanadium	73/141	−1	13	1	−1	3				5	5

1133654

Table 1 (*Continued*) (*Minus sign should be read as "less than" throughout*).

Muscle	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	135/137	1.0	1.5	1.2	1.1	1.2	1.2	0.25	0.02		
Ash % of dry	120/137	2.9	6.0	4.2	4.0	4.4	4.3	1.2	0.11		
G per 100 g of tissue ash											
Calcium	119/119	0.16	0.52	0.25	0.22	0.27	0.35	0.41	0.04		
Iron	120/120	0.21	0.51	0.34	0.32	0.36	0.35	0.12	0.01		
Magnesium	119/119	0.98	2.4	1.5	1.4	1.7	1.6	0.61	0.06		
Phosphorus	112/112	11	19	15	14	15	15	2.8	0.2		
Potassium	112/112	20	31	25	24	25	25	6.0	0.5		
μg per g of tissue ash											
Aluminum	136/136	6	77	16	13	20	36	82	7.1		
Copper	136/136	50	120	74	68	80	85	68	5.8		
Manganese	133/133	2	14	5	4	6	6	5.4	0.4		
Strontium	135/135	0.3	4.0	1.2	1.0	1.6	2.1	2.4	0.20		
Zinc	137/137	2900	6800	4300	4000	4600	4800	2200	190		
Barium	77/136	−0.2	2.7	0.3	−0.2	0.9				1.2	1.3
Bismuth	3/136	−2	−2	−2	−2	−2				0	2
Boron	6/137	−10	−10	−10	−10	−10				0	10
Cadmium	3/137	−50	−50	−50	−50	−50				22	71
Chromium	120/136	−0.1	5.0	1.0	0.7	1.2				2.3	2.3
Cobalt	6/136	−2	−2	−2	−2	−2				3	5
Gold	4/137	−10	−10	−10	−10	−10				0	10
Lead	65/136	−5	16	−5	−5	5				13	15
Molybdenum	2/136	−4	−4	−4	−4	−4				0	4
Nickel	30/136	−5	12	−5	−5	−5				4	8
Silver	27/135	−0.1	0.5	−0.1	−0.1	−0.1				0.1	0.2
Tin	26/137	−5	10	−5	−5	−5				4	8
Titanium	17/136	−5	5	−5	−5	−5				1	6
Vanadium	0/136	−1	−1	−1	−1	−1				0	1

1133655

Table 1 (Continued) (Minus sign should be read as "less than" throughout)

Ovary	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	16/16	0.80	1.4	0.97	0.90	1.1	1.0	0.20	0.05		
Ash % of dry	16/16	2.4	6.8	4.4	3.3	6.1	4.6	1.5	0.38		
G per 100 g of tissue ash											
Calcium	16/16	0.46	3.5	0.98	0.59	1.7	1.5	1.5	0.39		
Iron	16/16	0.22	0.94	0.43	0.34	0.68	0.59	0.50	0.13		
Magnesium	16/16	0.70	1.2	0.87	0.76	1.2	0.94	0.23	0.06		
Phosphorus	16/16	7	12	9	7	12	9	2.0	0.4		
Potassium	16/16	11	17	14	12	15	14	2.4	0.5		
μg per g of tissue ash											
Aluminum	16/16	12	150	36	20	110	60	58	15		
Copper	16/16	85	180	120	110	140	130	35	8.7		
Manganese	16/16	9	32	16	11	26	18	8.9	2.2		
Strontium	16/16	4.0	33	11	4.4	19	15	15	3.7		
Zinc	16/16	840	2700	1700	1200	2400	1800	850	210		
Barium	14/16	−0.2	8.7	2.9	1.2	6.4				5.0	5.0
Bismuth	1/16	−2	−2	−2	−2	−2				0	2
Boron	3/16	−10	17	−10	−10	−10				2	11
Cadmium	5/16	−50	78	−50	−50	50				31	65
Chromium	16/16	0.7	150	2.2	0.9	9.4	49	130	32		
Cobalt	0/16	−2	−2	−2	−2	−2				0	2
Gold	5/16	−10	23	−10	−10	10				5	13
Lead	12/16	−5	27	13	−5	16				13	14
Molybdenum	0/16	−4	−4	−4	−4	−4				0	4
Nickel	4/16	−5	17	−5	−5	10				3	7
Silver	7/16	−0.1	1.1	−0.1	−0.1	0.5				0.2	0.3
Tin	13/16	−5	210	15	5	35				53	54
Titanium	6/16	−5	13	−5	−5	7				3	6
Vanadium	0/16	−1	−1	−1	−1	−1				0	1

1133b5b

Table 1 (Continued) (Minus sign should be read as "less than" throughout)

Omentum	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	73/75	0.08	0.50	0.20	0.17	0.20	0.25	0.19	0.02		
Ash % of dry	72/75	0.1	0.8	0.2	0.2	0.2	0.3	0.32	0.04		
G per 100 g of tissue ash											
Calcium	72/72	0.51	2.2	1.1	0.96	1.3	1.3	0.70	0.08		
Iron	73/73	0.50	2.5	1.1	0.90	1.5	1.4	0.91	0.11		
Magnesium	72/72	0.65	1.9	1.2	1.0	1.3	1.2	0.47	0.06		
Phosphorus	71/71	6	13	9	8	9	9	3.0	0.3		
Potassium	71/71	11	23	18	16	20	18	4.5	0.5		
μg per g of tissue ash											
Aluminum	75/75	68	1100	180	130	260	520	1100	130		
Copper	75/75	110	280	190	170	200	190	82	9.4		
Manganese	75/75	13	78	29	23	36	48	85	9.8		
Strontium	74/74	3.6	25	9.5	6.8	12	12	10	1.2		
Zinc	73/73	940	2900	1600	1400	1800	1700	750	88		
Barium	74/75	2.9	27	7.0	5.2	10				11	11
Bismuth	10/74	−2	4	−2	−2	−2				13	15
Boron	13/74	−10	10	−10	−10	−10				3	11
Cadmium	31/74	−50	100	−50	−50	50				42	71
Chromium	75/75	2.3	32	12	8.0	14	14	14	1.7		
Cobalt	26/75	−2	12	−2	−2	−2				7	8
Gold	24/74	−10	44	−10	−10	−10				11	18
Lead	72/74	7	220	30	27	36				140	140
Molybdenum	12/75	−4	5	−4	−4	−4				1	4
Nickel	63/75	−5	76	22	15	28				33	34
Silver	61/74	−0.1	1.5	0.5	0.4	0.7				0.7	0.7
Tin	69/74	5	48	16	11	21				29	29
Titanium	67/75	−5	74	21	17	28				34	34
Vanadium	11/75	−1	3	−1	−1	−1				0	1

1133657

Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Pancreas	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	136/139	0.70	1.5	1.2	1.1	1.2	1.1	0.38	0.03		
Ash % of dry	120/139	0.8	5.6	3.5	2.5	3.8	3.3	1.8	0.17		
G per 100 g of tissue ash											
Calcium	119/119	0.50	1.4	0.78	0.72	0.83	0.88	0.45	0.04		
Iron	119/119	0.16	0.80	0.37	0.33	0.42	0.46	0.38	0.03		
Magnesium	119/119	0.94	2.0	1.4	1.3	1.5	1.4	0.43	0.04		
Phosphorus	114/114	15	24	20	19	20	20	3.8	0.3		
Potassium	113/113	15	26	20	19	21	20	4.3	0.4		
μg per g of tissue ash											
Aluminum	138/138	12	160	27	21	32	66	150	12		
Copper	138/138	92	210	140	130	150	150	76	6.4		
Manganese	138/138	54	200	98	90	100	110	58	4.9		
Strontium	139/139	1.5	9.5	3.3	3.0	4.2	4.9	4.9	0.41		
Zinc	138/138	1500	3500	2300	2200	2400	2400	820	70		
Barium	108/139	−0.2	4.6	1.6	1.2	2.0				2.5	2.5
Bismuth	13/139	−2	−2	−2	−2	−2				1	3
Boron	40/139	−10	12	−10	−10	−10				4	11
Cadmium	120/139	−50	200	80	70	100				98	110
Chromium	122/139	−0.1	6.8	1.6	1.1	2.0				3.7	3.7
Cobalt	13/139	−2	−2	−2	−2	−2				1	3
Gold	19/139	−10	10	−10	−10	−10				3	12
Lead	138/138	18	130	49	41	53	69	80	6.8		
Molybdenum	12/139	−4	−4	−4	−4	−4				0	4
Nickel	26/139	−5	11	−5	−5	−5				6	11
Silver	61/137	−0.1	1.0	−0.1	−0.1	0.1				0.3	0.3
Tin	73/139	−5	24	5	−5	5				14	16
Titanium	29/139	−5	16	−5	−5	−5				7	12
Vanadium	2/139	−1	−1	−1	−1	−1				0	1

1133658

Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Prostate	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	49/51	0.80	1.6	1.1	1.0	1.2	1.2	0.33	0.05		
Ash % of dry	41/51	2.0	6.8	4.5	3.6	4.7	4.4	1.8	0.28		
G per 100 g of tissue ash											
Calcium	40/40	1.2	4.0	2.1	1.6	2.6	2.4	1.3	0.20		
Iron	39/39	0.14	0.54	0.24	0.20	0.28	0.32	0.36	0.06		
Magnesium	40/40	1.1	2.2	1.5	1.4	1.8	1.6	0.39	0.06		
Phosphorus	36/36	7	12	9	9	10	9	2.6	0.4		
Potassium	36/36	12	26	18	16	21	18	5.2	0.8		
μg per g of tissue ash											
Aluminum	50/50	12	220	46	30	68	270	1400	200		
Copper	50/50	57	140	100	85	110	110	48	6.8		
Manganese	50/50	7	28	14	12	16	19	21	2.9		
Strontium	48/48	5.0	48	11	8.8	14	16	16	2.3		
Zinc	50/50	3200	19000	7500	6000	8100	9200	6100	860		
Barium	44/50	−0.2	9.9	2.1	1.5	2.8				4.2	4.2
Bismuth	3/50	−2	−2	−2	−2	−2				0	2
Boron	9/50	−10	10	−10	−10	−10				2	11
Cadmium	20/50	−50	95	−50	−50	50				31	61
Chromium	41/50	−0.1	6.0	0.9	0.5	1.5				2.2	2.3
Cobalt	3/50	−2	−2	−2	−2	−2				1	3
Gold	10/50	−10	29	−10	−10	−10				6	14
Lead	44/50	−5	81	10	9	14				26	27
Molybdenum	2/50	−4	−4	−4	−4	−4				0	4
Nickel	8/50	−5	5	−5	−5	−5				4	8
Silver	24/48	−0.1	1.3	−0.1	−0.1	0.1				0.9	1.0
Tin	42/50	−5	39	14	10	18				20	21
Titanium	16/50	−5	33	−5	−5	−5				16	20
Vanadium	1/50	−1	−1	−1	−1	−1				0	1

1133659

Table 1 (Continued) (Minus sign should be read as "less than" throughout)

Spleen	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	140/143	1.1	1.6	1.4	1.3	1.4	1.4	0.34	0.03		
Ash % of dry	124/143	3.3	6.4	5.0	4.8	5.3	5.0	1.5	0.13		
G per 100 g of tissue ash											
Calcium	122/122	0.28	0.78	0.50	0.44	0.55	0.60	0.60	0.05		
Iron	124/124	0.90	4.2	2.2	1.9	2.5	2.4	1.5	0.14		
Magnesium	123/123	0.70	1.5	0.92	0.88	1.0	1.0	0.31	0.03		
Phosphorus	115/115	12	19	16	15	16	16	2.9	0.2		
Potassium	114/114	18	28	23	22	23	23	5.1	0.4		
μg per g of tissue ash											
Aluminum	143/143	10	120	25	21	30	74	180	15		
Copper	143/143	67	120	89	84	93	93	37	3.1		
Manganese	143/143	5	19	9	8	11	11	10	0.8		
Strontium	143/143	1.1	6.0	2.1	2.0	2.6	3.4	5.3	0.45		
Zinc	142/142	1000	1900	1300	1300	1400	1400	340	29		
Barium	89/143	−0.2	3.3	0.6	0.2	1.0				1.5	1.6
Bismuth	8/143	−2	−2	−2	−2	−2				0	2
Boron	21/143	−10	10	−10	−10	−10				1	10
Cadmium	18/143	−50	50	−50	−50	−50				10	54
Chromium	113/143	−0.1	3.2	0.5	0.2	0.8				1.3	1.3
Cobalt	8/143	−2	−2	−2	−2	−2				1	3
Gold	6/143	−10	−10	−10	−10	−10				1	11
Lead	138/143	7	90	27	24	32				58	59
Molybdenum	4/143	−4	−4	−4	−4	−4				0	4
Nickel	17/143	−5	5	−5	−5	−5				2	6
Silver	44/141	−0.1	0.5	−0.1	−0.1	−0.1				0.3	0.3
Tin	120/143	−5	35	11	10	14				17	17
Titanium	31/143	−5	14	−5	−5	−5				5	9
Vanadium	1/143	−1	−1	−1	−1	−1				0	1

1133660

Table 1 (Continued) (Minus sign should be read as "less than" throughout)

Skin	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	21/22	0.50	0.97	0.70	0.60	0.90	0.79	0.32	0.07		
Ash % of dry	19/22	1.1	2.8	1.7	1.4	2.3	2.0	0.92	0.21		
G per 100 g of tissue ash											
Calcium	19/19	1.5	2.5	2.1	1.8	2.4	2.0	0.51	0.12		
Iron	19/19	0.10	0.33	0.17	0.11	0.20	0.19	0.12	0.03		
Magnesium	19/19	0.60	1.1	0.86	0.74	0.92	0.87	0.22	0.05		
Phosphorus	19/19	4	6	4	4	5	4	1.4	0.3		
Potassium	19/19	6	15	11	9	13	11	3.2	0.7		
μg per g of tissue ash											
Aluminum	22/22	72	1200	260	140	370	400	450	95		
Copper	22/22	80	150	100	94	120	120	53	11		
Manganese	22/22	6	17	13	8	14	22	49	10		
Strontium	21/21	4.5	15	8.6	5.4	14	13	16	3.5		
Zinc	21/21	550	1000	780	680	840	1000	1000	230		
Barium	22/22	4.0	35	8.2	5.0	23	17	19	3.9	1	3
Bismuth	2/22	−2	−2	−2	−2	−2				15	21
Boron	8/22	−10	24	−10	−10	10				0	50
Cadmium	0/22	−50	−50	−50	−50	−50					
Chromium	22/22	9.0	86	17	12	31	41	63	13	3	5
Cobalt	5/22	−2	11	−2	−2	−2				2	10
Gold	4/22	−10	10	−10	−10	−10				59	60
Lead	21/22	16	120	46	21	100				1	5
Molybdenum	2/22	−4	−4	−4	−4	−4				110	110
Nickel	21/22	15	180	47	19	110				1.8	1.8
Silver	21/22	0.1	4.0	1.3	0.8	2.5				36	37
Tin	21/22	7	74	21	14	60					
Titanium	22/22	17	100	32	22	64	72	130	28	0	1
Vanadium	3/21	−1	1	−1	−1	−1					

1133661

Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Stomach	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	129/131	0.60	0.97	0.80	0.70	0.80	0.82	0.40	0.03		
Ash % of dry	114/131	1.5	4.5	3.2	2.8	3.3	3.3	2.1	0.20		
G per 100 g of tissue ash											
Calcium	110/110	0.49	1.8	0.90	0.80	1.0	1.1	1.0	0.10		
Iron	110/110	0.19	0.73	0.37	0.34	0.43	0.43	0.23	0.02		
Magnesium	110/110	0.90	2.0	1.4	1.3	1.6	1.5	0.47	0.04		
Phosphorus	105/105	11	19	15	14	16	15	3.0	0.2		
Potassium	104/104	14	23	18	17	19	18	3.9	0.3		
μg per g of tissue ash											
Aluminum	130/130	16	110	35	33	42	110	400	35		
Copper	130/130	150	320	230	220	240	230	66	5.8		
Manganese	129/129	22	74	42	35	46	47	28	2.5		
Strontium	130/130	3.4	28	9.9	8.0	12	13	11	0.93		
Zinc	130/130	1700	3400	2400	2300	2600	2600	790	69		
Barium	126/130	0.9	8.8	3.2	2.5	3.7				5.6	5.6
Bismuth	9/131	−2	−2	−2	−2	−2				20	22
Boron	48/131	−10	20	−10	−10	−10				7	13
Cadmium	49/131	−50	80	−50	−50	−50				28	60
Chromium	118/130	0.1	6.6	2.0	1.5	2.4				4.1	4.1
Cobalt	15/131	−2	2	−2	−2	−2				2	3
Gold	17/131	−10	10	−10	−10	−10				2	11
Lead	123/131	5	35	12	10	14				25	25
Molybdenum	11/130	−4	4	−4	−4	−4				1	4
Nickel	44/130	5	18	−5	5	−5				4	8
Silver	52/130	−0.1	1.0	−0.1	−0.1	−0.1				1.5	1.5
Tin	111/131	−5	74	16	14	20				42	43
Titanium	26/130	−5	5	−5	−5	−5				9	13
Vanadium	3/130	−1	−1	−1	−1	−1				0	1

1133662

Table 1 (*Continued*) (*Minus sign should be read as "less than" throughout*).

Testis	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	72/72	0.90	1.3	1.1	1.0	1.1	1.1	0.19	0.02		
Ash % of dry	68/72	3.0	7.8	5.7	5.2	6.6	5.8	1.9	0.23		
G per 100 g of tissue ash											
Calcium	68/68	0.64	1.4	0.86	0.80	0.94	0.96	0.35	0.04		
Iron	68/68	0.14	0.45	0.21	0.19	0.25	0.26	0.13	0.02		
Magnesium	68/68	0.78	1.5	1.0	0.95	1.1	1.1	0.30	0.04		
Phosphorus	65/65	7	16	12	11	12	12	3.7	0.4		
Potassium	67/67	12	24	18	18	20	19	4.2	0.5		
μg per g of tissue ash											
Aluminum	72/72	16	80	30	25	40	46	57	6.7		
Copper	71/71	58	110	80	72	86	95	100	12		
Manganese	72/72	8	21	12	11	14	14	5.7	0.6		
Strontium	69/69	1.9	13	4.3	3.7	5.2	5.8	4.5	0.54		
Zinc	71/71	900	2200	1400	1300	1600	1500	540	64		
Barium	54/72	−0.2	3.6	1.1	0.4	1.7				1.4	1.5
Bismuth	16/72	−2	18	−2	−2	−2				7	8
Boron	1/72	−10	−10	−10	−10	−10				0	10
Cadmium	11/72	−50	50	−50	−50	−50				10	53
Chromium	66/72	0.1	6.3	1.6	1.1	2.0				2.4	2.4
Cobalt	6/72	−2	−2	−2	−2	−2				6	8
Gold	11/72	−10	10	−10	−10	−10				3	12
Lead	68/72	5	27	12	10	15				15	16
Molybdenum	2/72	−4	−4	−4	−4	−4				0	4
Nickel	17/72	−5	16	−5	−5	−5				7	11
Silver	24/71	−0.1	0.5	−0.1	−0.1	−0.1				0.4	0.5
Tin	54/72	−5	33	11	5	15				16	17
Titanium	19/72	−5	10	−5	−5	−5				3	7
Vanadium	0/72	−1	−1	−1	−1	−1				0	1

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Table 1 (Continued) (Minus sign should be read as "less than" throughout)

Thyroid	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	20/21	0.81	1.8	1.1	0.95	1.2	1.4	1.4	0.30		
Ash % of dry	14/21	2.3	6.4	3.7	2.9	6.0	5.0	4.1	1.1		
G per 100 g of tissue ash											
Calcium	14/14	1.2	4.0	3.0	2.0	4.0	2.8	1.2	0.31		
Iron	14/14	0.16	0.68	0.46	0.21	0.55	0.44	0.21	0.06		
Magnesium	14/14	0.23	1.5	0.90	0.45	1.3	0.98	0.71	0.19		
Phosphorus	10/10	4	8	7	4	8	6	1.9	0.6		
Potassium	10/10	2	16	12	7	15	11	4.2	1.3		
μg per g of tissue ash											
Aluminum	21/21	35	240	85	50	180	190	310	68		
Copper	20/20	43	240	94	68	100	100	62	14		
Manganese	21/21	9	35	17	13	24	19	11	2.3		
Strontium	21/21	5.3	21	13	11	17	13	6.2	1.3		
Zinc	21/21	1700	4000	2700	2100	3200	2900	1200	260		
Barium	20/21	1.8	33	5.8	3.2	9.0				16	16
Bismuth	4/21	−2	2	−2	−2	−2				3	5
Boron	3/21	−10	10	−10	−10	−10				2	11
Cadmium	14/21	−50	190	50	−50	120				83	100
Chromium	18/21	−0.1	5.0	1.5	0.1	4.0				2.5	2.5
Cobalt	3/21	−2	3	−2	−2	−2				2	4
Gold	3/21	−10	16	−10	−10	−10				3	12
Lead	20/21	5	54	10	10	20				21	22
Molybdenum	1/21	−4	−4	−4	−4	−4				0	4
Nickel	7/21	−5	10	−5	−5	5				3	6
Silver	10/20	−0.1	9.8	−0.1	−0.1	2.0				2.8	2.8
Tin	16/21	−5	47	13	5	38				22	23
Titanium	11/21	−5	82	5	−5	15				26	28
Vanadium	1/21	−1	−1	−1	−1	−1				0	1

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Table 1 (Continued) (Minus sign should be read as "less than" throughout)

Trachea	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	60/60	1.2	2.9	1.6	1.5	1.9	1.9	0.83	0.11		
Ash % of dry	58/60	3.4	8.7	5.4	4.8	5.9	5.7	2.1	0.27		
G per 100 g of tissue ash											
Calcium	57/57	2.0	9.0	3.6	3.0	5.2	4.5	2.9	0.38		
Iron	56/56	0.12	0.60	0.26	0.20	0.34	0.31	0.21	0.03		
Magnesium	57/57	0.71	1.8	1.2	1.0	1.3	1.2	0.40	0.05		
Phosphorus	55/55	4	8	5	4	6	5	3.5	0.4		
Potassium	55/55	4	16	11	9	12	11	4.5	0.6		
μg per g of tissue ash											
Aluminum	60/60	12	890	57	34	100	220	410	53		
Copper	60/60	25	96	56	45	68	65	61	7.9		
Manganese	54/54	7	24	12	10	14	14	7.4	1.0		
Strontium	60/60	9.5	47	18	15	20	23	18	2.4		
Zinc	60/60	450	1800	890	780	1100	980	480	62		
Barium	60/60	1.0	13	5.0	3.9	5.8	6.2	5.6	0.72	13	15
Bismuth	5/60	−2	−2	−2	−2	−2				10	18
Boron	14/60	−10	13	−10	−10	−10				6	50
Cadmium	7/60	−50	50	−50	−50	−50				4.7	4.8
Chromium	53/60	−0.1	8.8	3.4	1.2	4.5				1	3
Cobalt	13/60	−2	4	−2	−2	−2				13	20
Gold	20/60	−10	41	−10	−10	−10					
Lead	60/60	15	120	44	34	60	58	43	5.6	0	4
Molybdenum	1/60	−4	−4	−4	−4	−4				7	10
Nickel	31/60	−5	15	5	−5	6				0.6	0.6
Silver	32/60	−0.1	1.3	0.1	−0.1	0.4				31	32
Tin	54/60	−5	50	12	10	18				35	37
Titanium	28/60	−5	73	−5	−5	8				0	1
Vanadium	0/60	−1	−1	−1	−1	−1					

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Table 1 (Continued) (Minus sign should be read as "less than" throughout).

Urinary bladder	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	109/113	0.50	1.1	0.80	0.70	0.80	0.78	0.26	0.02		
Ash % of dry	101/113	0.9	4.1	2.3	2.0	2.6	2.4	1.2	0.12		
G per 100 g of tissue ash											
Calcium	98/98	0.80	2.1	1.3	1.2	1.5	1.4	0.55	0.06		
Iron	99/99	0.16	0.79	0.31	0.25	0.35	0.38	0.26	0.03		
Magnesium	98/98	0.86	2.3	1.4	1.3	1.5	1.4	0.52	0.05		
Phosphorus	96/96	7	13	9	8	9	9	2.6	0.2		
Potassium	95/95	14	24	18	17	20	19	3.9	0.4		
μg per g of tissue ash											
Aluminum	110/110	18	150	47	40	57	100	230	22		
Copper	110/110	76	180	110	110	120	120	48	4.6		
Manganese	109/109	6	40	13	11	15	18	18	1.7		
Strontium	110/110	5.5	23	12	10	13	14	11	1.1		
Zinc	112/112	1800	4900	3000	2700	3300	3200	1400	130		
Barium	106/110	0.6	8.0	3.4	2.6	4.0				6.4	6.4
Bismuth	9/110	−2	−2	−2	−2	−2				3	5
Boron	28/112	−10	19	−10	−10	−10				7	15
Cadmium	34/112	−50	66	−50	−50	−50				22	57
Chromium	103/110	0.4	13	3.4	2.5	4.2				10	10
Cobalt	12/110	−2	2	−2	−2	−2				3	5
Gold	22/112	−10	30	−10	−10	−10				9	18
Lead	99/112	−5	41	13	10	15				22	23
Molybdenum	6/110	−4	−4	−4	−4	−4				1	5
Nickel	46/110	−5	20	−5	−5	5				9	12
Silver	46/112	−0.1	0.7	−0.1	−0.1	0.1				0.3	0.3
Tin	100/112	−5	58	16	11	20				29	30
Titanium	43/110	−5	29	−5	−5	−5				20	23
Vanadium	3/110	−1	−1	−1	−1	−1				0	1

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Table 1 (*Continued*) (*Minus sign should be read as "less than" throughout*).

Uterus	Fraction observed	80 per cent range		Median	95 per cent confidence interval for median		Mean	Std. dev.	Std. error	Range of mean	
Ash % of wet	32/32	0.90	1.2	0.98	0.90	1.1	1.0	0.14	0.02		
Ash % of dry	30/32	2.9	5.7	4.3	3.9	4.7	4.3	0.96	0.18		
G per 100 g of tissue ash											
Calcium	30/30	0.50	3.2	0.92	0.78	1.3	1.4	1.1	0.20		
Iron	29/29	0.13	0.62	0.29	0.19	0.37	0.31	0.17	0.03		
Magnesium	30/30	0.80	1.7	1.1	1.0	1.1	1.1	0.32	0.06		
Phosphorus	28/28	8	14	11	9	12	11	2.3	0.4		
Potassium	28/28	11	24	20	15	21	18	5.1	0.9		
μg per g of tissue ash											
Aluminum	32/32	12	90	36	22	52	47	39	6.9		
Copper	32/32	73	130	98	90	110	110	54	9.5		
Manganese	31/31	7	20	10	8	14	12	7.4	1.3		
Strontium	32/32	2.3	21	9.5	4.0	14	11	9.9	1.7		
Zinc	32/32	1300	3400	1900	1500	2800	2500	1700	290		
Barium	27/32	−0.2	5.5	2.0	0.9	2.9				3.0	3.1
Bismuth	2/32	−2	−2	−2	−2	−2				0	2
Boron	4/32	−10	10	−10	−10	−10				1	10
Cadmium	5/32	−50	50	−50	−50	−50				9	52
Chromium	28/32	−0.1	10	1.6	0.9	2.9				16	16
Cobalt	3/32	−2	−2	−2	−2	−2				2	4
Gold	1/32	−10	−10	−10	−10	−10				0	11
Lead	20/32	−5	29	5	−5	10				12	13
Molybdenum	1/32	−4	−4	−4	−4	−4				0	4
Nickel	6/32	−5	6	−5	−5	−5				8	13
Silver	10/32	−0.1	0.6	−0.1	−0.1	0.1				0.1	0.2
Tin	24/32	−5	65	10	6	20				21	22
Titanium	5/32	−5	5	−5	−5	−5				4	8
Vanadium	1/32	−1	−1	−1	−1	−1				0	1

Table 1. Concentrations as indicated. For elements the column "Fraction observed", indicates the number of samples in which an element was observed above the limits of detection divided by the number of samples in which a determination of that element was made. For Ash per cent of Wet and Ash per cent of Dry the fraction is the number of samples for which values for these parameters were available divided by the total number of samples of the tissue analyzed.

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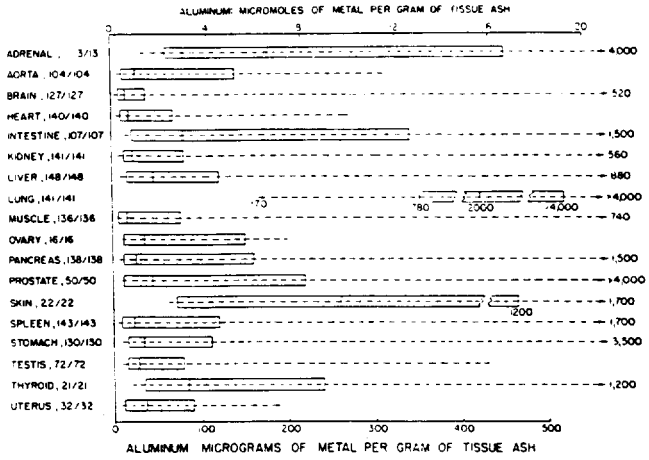

Fig. 1a

FIG. 1. Distribution of elements among tissues.

For potassium and phosphorus the mean plus and minus twice the standard error of the mean are represented by the central line and two ends of the bar.

For all other elements and for the per cent ash of wet and per cent ash of dry, the central vertical line represents the median, the ends of the bar the 10th and 90th percentiles, and the dotted line the total range. The lower limit of detection of an element is indicated by a vertical line.

For all elements the numbers after the names of tissues indicate the number of samples in which the element was observed divided by the total number of samples in which a determination of that element was made. For ash per cent of wet and ash per cent of dry the numbers indicate the number of samples for which values for these parameters were available.

The word "intestine" as used in the figure refers to the data for sigmoid colon.

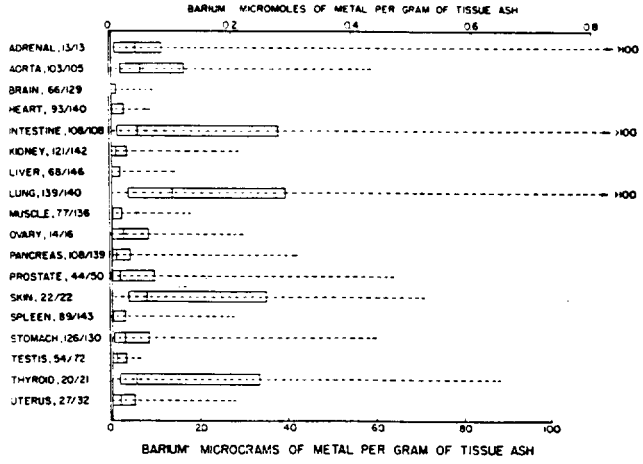

Fig. 1b

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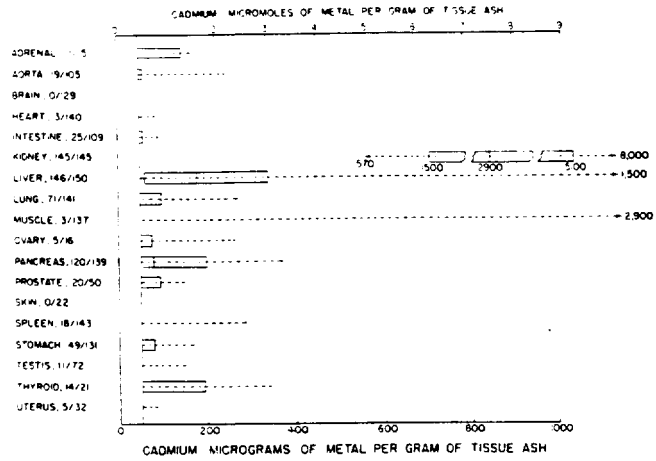

Fig. 1c

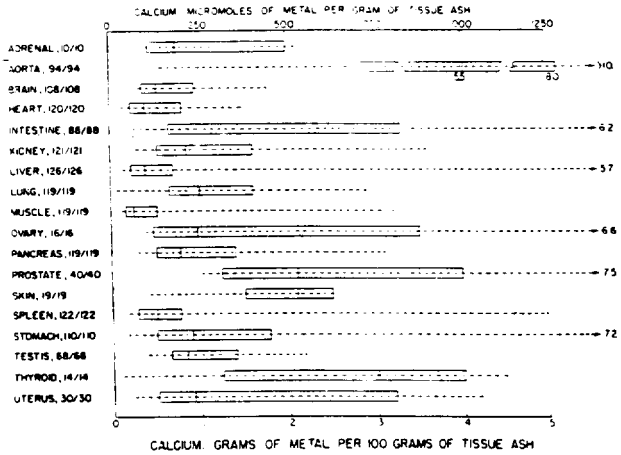

Fig. 1d

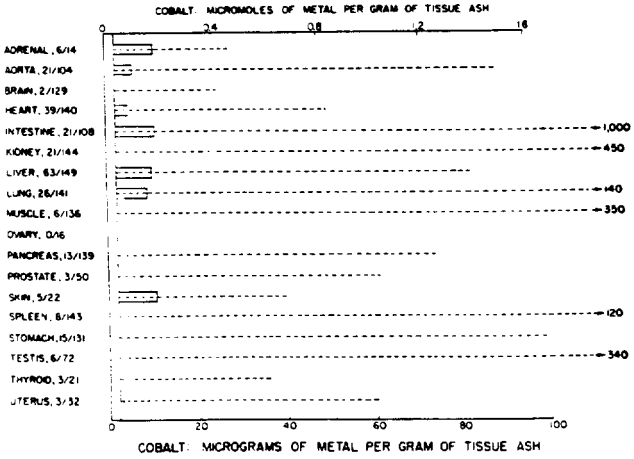

Fig. 1e

1133669

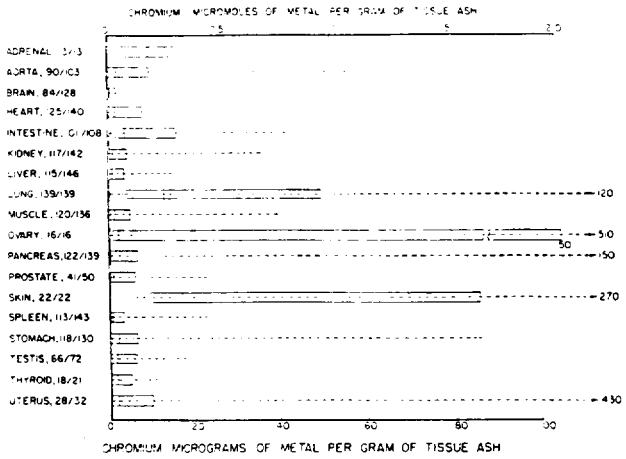

Fig. 1f

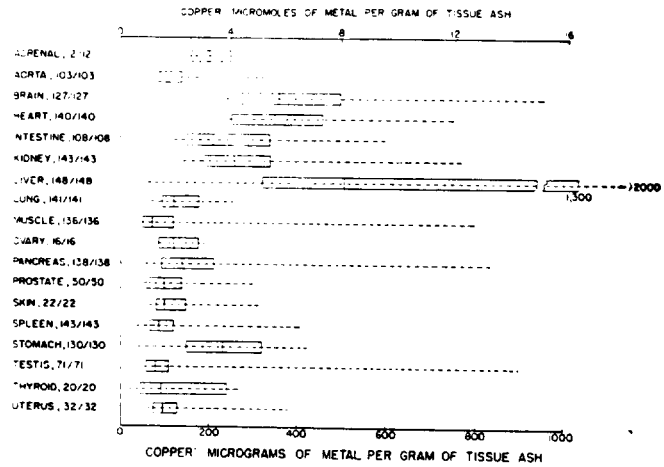

Fig. 1g

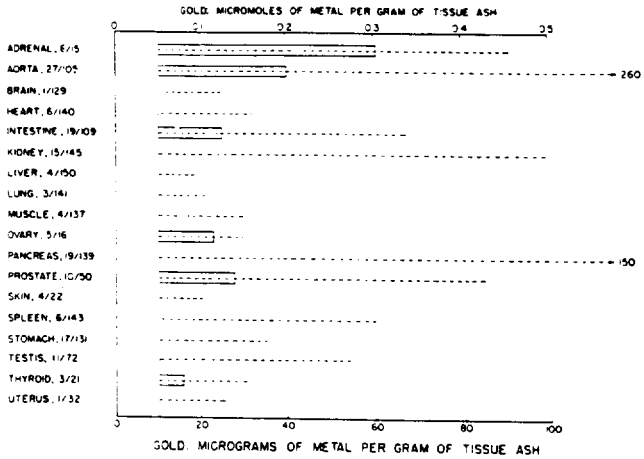

Fig. 1h

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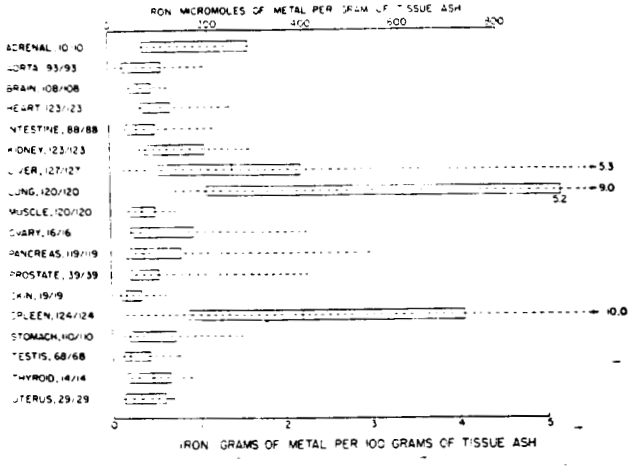

Fig. 1i

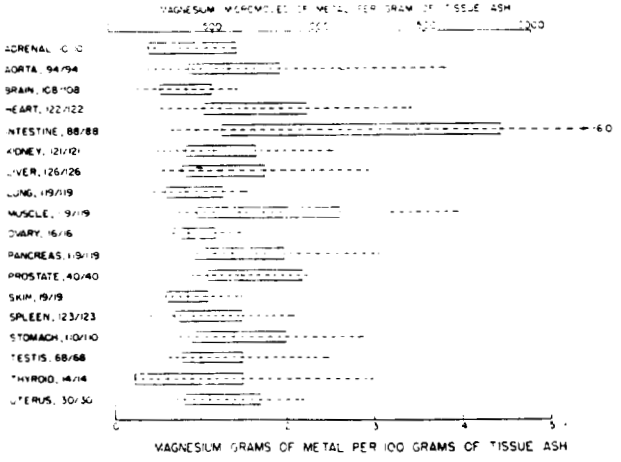

Fig. 1j

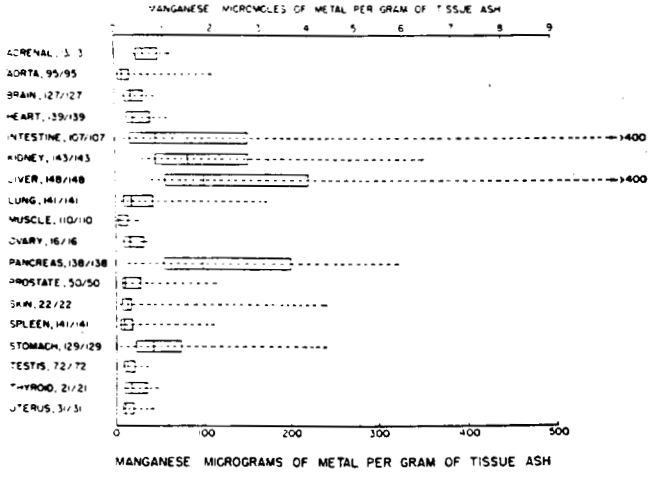

Fig. 1k

1133671

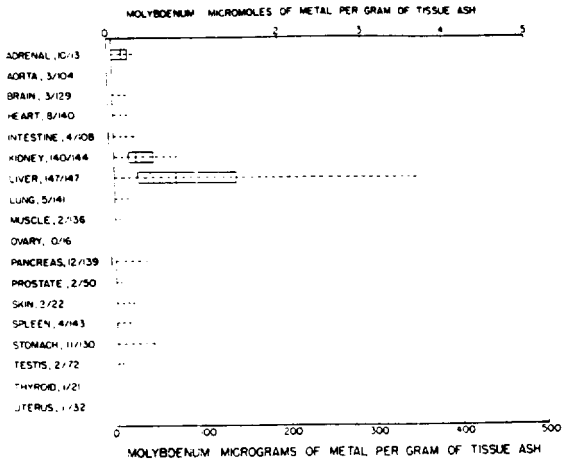

Fig. 11

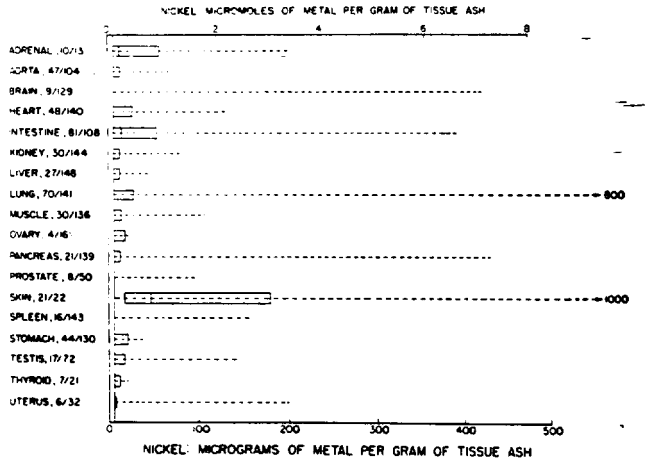

Fig. 1m

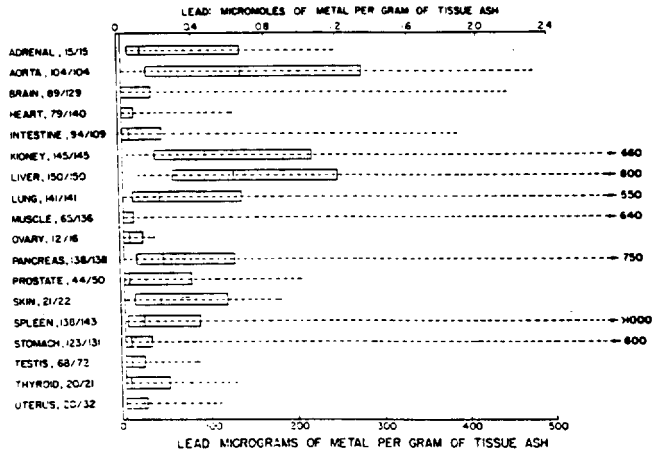

Fig. 1n

1133672

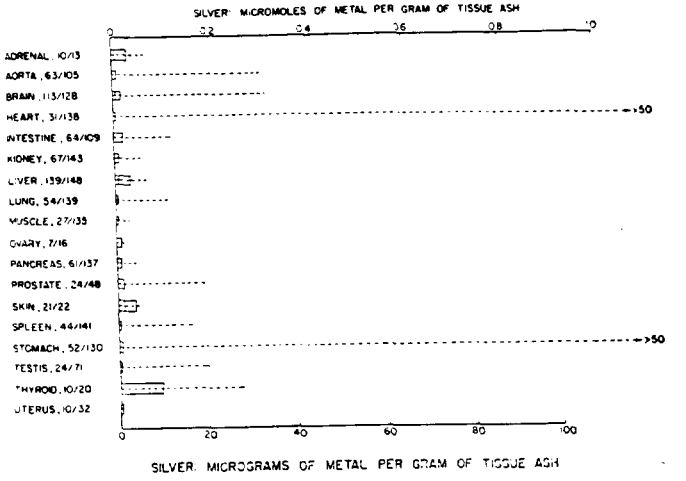

Fig. 1o

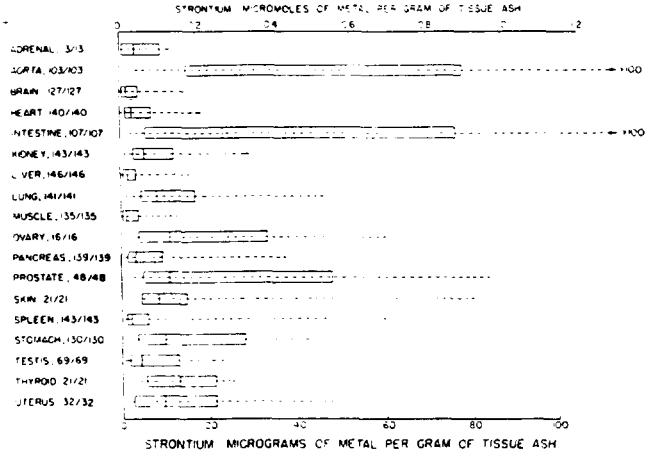

Fig. 1p

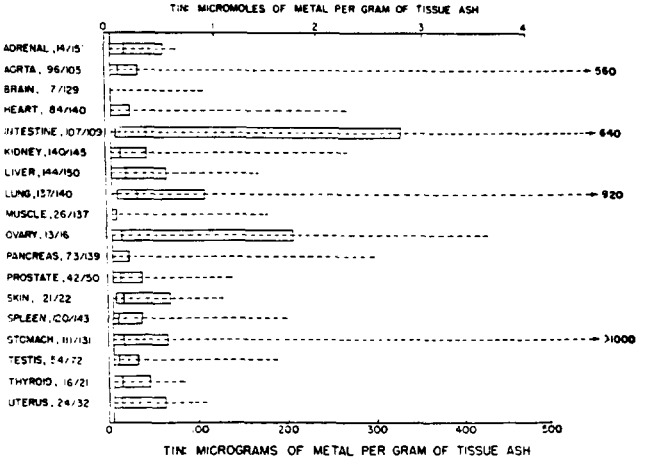

Fig. 1q

1133673

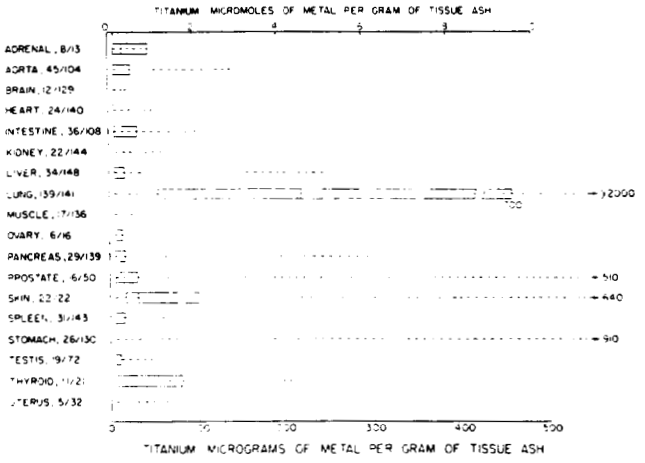

Fig. 1r

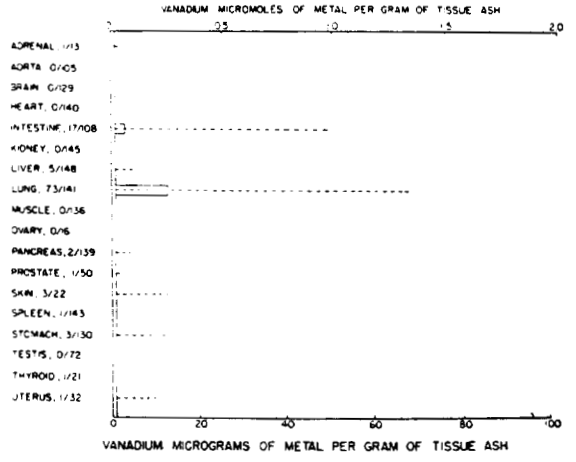

Fig. 1s

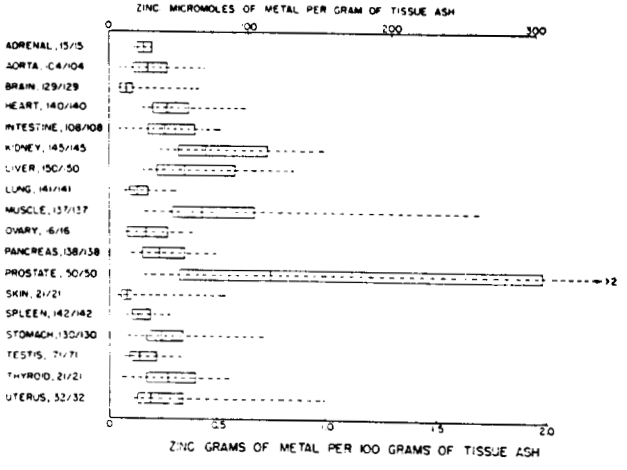

Fig. 1t

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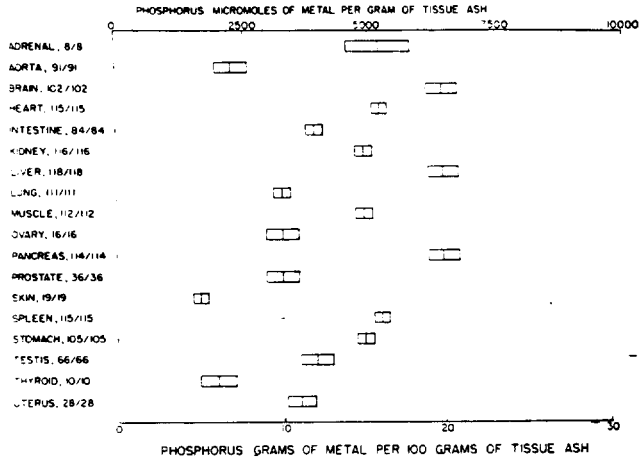

Fig. 1u

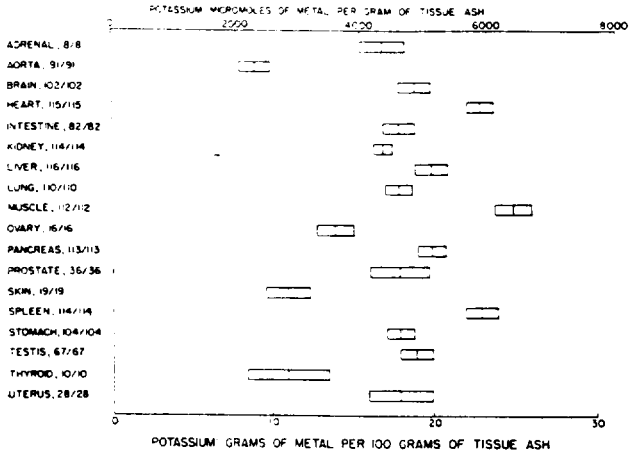

Fig. 1v

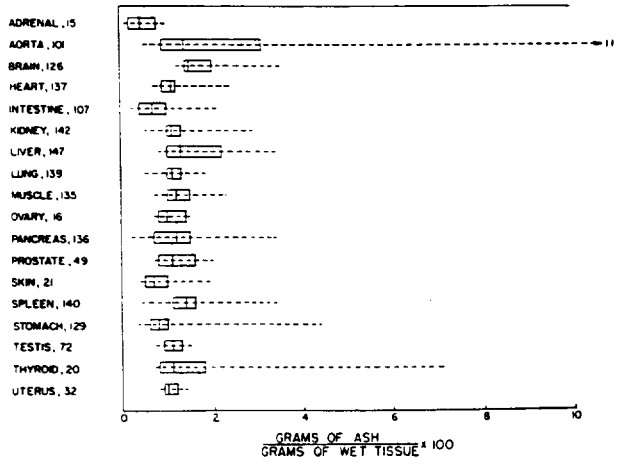

Fig. 1w

1133675

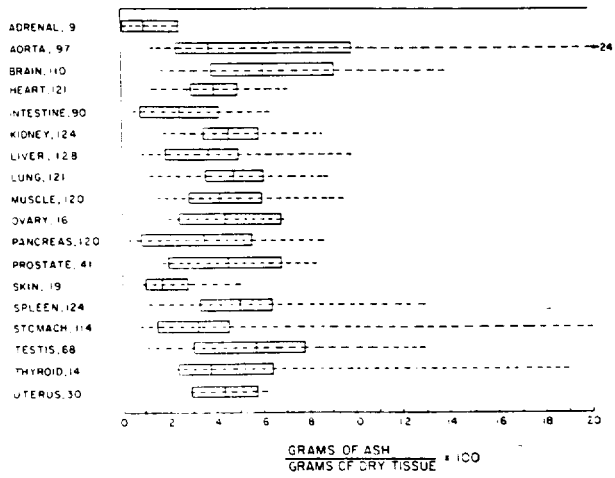

Fig. 1x

to have a role in the body, would be classified as non-essential elements. Although these criteria are not true indices of the essentiality of an element, they will be used in the following discussion to indicate to what extent an element behaves like an essential or a non-essential element.

SCHROEDER and BALASSA and their co-workers, in their series on "Abnormal Trace Metals in Man" have discussed rather fully the occurrence and probable source of cadmium,[15] lead,[16] chromium,[17] nickel[18] and titanium[19] in man. In a later paper in the series of which this paper is the second, correlations between elements and the influence of age, geographical location and other variables on the concentrations of elements in tissues will be discussed. The following brief discussions will summarize the results obtained in the U.T.-ORNL program for spectrographic analyses of human tissue and, where possible, compare them with those of other observers who have made the same kind of study.

Aluminum was observed above the limit of detection in every sample of every tissue. It is the only "non-essential" element except strontium which was observed in every sample. In any one tissue the variation in the concentration of aluminum from sample to sample was wide, and the median values showed a wide variation from tissue to tissue. Those tissues which were exposed to the outside environment, i.e. lung and skin, showed the greatest concentration; in fact the median value for lung was two orders of magnitude higher than for other soft tissues except skin.

Values for aluminum reported here are somewhat lower than, though generally of the same order of magnitude as, those reported by HARDING-BARLOW,[4] STITCH,[6] KOCH[7] and KEHOE *et al.*[20] They agree very well with those of KOIRTYOHANN and FELDMAN.[23] They are much lower than those reported by TIETZ[3] and by BUTT and NUSBAUM.[2] The latter have indicated[21] that their extremely high values were perhaps due to contamination from the containers in which their samples were ashed.

Barium was observed above the limit of detection in about 80 per cent of all the samples analyzed. The median values were generally low, approaching the limits of detection for over half of the tissues. The tissues—intestine, lung, skin and thyroid—in which barium occurred in highest concentration also showed the widest variation. The values reported here are in general lower than those of HARDING-BARLOW[4] and of SOWDEN.[22] This "non-essential" element behaves to some extent like an essential element.

Cadmium was observed in every sample of kidney, in almost every sample of liver and pancreas, and less frequently in other tissues.

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The lower limit of detection of the method was fairly high. KOIRTYOHANN and FELDMAN[23] using a more sensitive line for cadmium have observed this element in concentrations of about half of this lower limit in every one of the 200 or more samples of various tissues which they have analyzed. The variation of cadmium in kidney and liver with age and geography and the apparent lack of a mechanism for control of this element have been discussed elsewhere.[10,24]

Calcium was observed to occur in highest concentration and with greatest variability in the aorta. Thyroid, skin and prostate had concentrations about half as great as aorta and two to four times as great as the other soft tissues which had concentrations in ash of 1 per cent or less. The mean value for calcium reported here, when calculated on the basis of wet tissue (64 ± 6.5 μg/g) is over three times that observed by THIERS and VALLEE (17.4 ± 5.1 μg/g).

Chromium was observed in almost every sample. For the most part the median value of the concentration was close to the lower limit of detection. In lung and in skin, however, the concentrations were higher and more variable than in other tissues. The low variability of chromium in liver is compatible with the observation by SCHWARZ and MERTZ[25] of chromium as an essential part of a glucose tolerance factor in canine livers. The values for this element reported here are similar to those found by KOCH *et al.*[7] and by KOIRTYOHANN and FELDMAN,[23] are somewhat lower than those of HARDING-BARLOW[4] and are very much lower than those of BUTT *et al.*[2] and of TIETZ *et al.*[3]

Cobalt was observed in less than a fourth of all samples analyzed, and in about 40 per cent of all the samples of liver. The method was not sensitive enough to measure the low concentrations of cobalt which occur in tissue.

Copper was highest and most variable in the liver, next highest in brain, heart, kidney and intestine. The concentrations of copper in the ash of most of the other soft tissues were fairly constant at about 100 μg/g. In general the values reported here agree very well with those of other observers.[2,4,7,20,23,26,27,28] The mean value for the concentration of copper in liver when converted to a basis of wet tissue (8.9 ± 0.65 μg/g) is about twice that reported by THIERS and VALLEE for perfused rat liver (4.7 ± 0.47 μg/g). This difference can be attributed not only to a species difference but also to the fact that the blood was not removed from the U.T.-ORNL samples before ashing.

Gold showed no consistent pattern, occurring above the limits of detection in almost every tissue but in very few samples of any one. This element was observed with greatest frequency in adrenal and aorta and in highest concentrations in aorta.

Iron was highest and most variable in those tissues which contained the most blood, that is, the lung, liver and spleen. The concentration of this element in the rest of the soft tissues was fairly constant at 0.5 per cent or less. In general there is good agreement between the values reported here and those of other observers.[2,3,4,26,29] The discrepancy between the values obtained by THIERS and VALLEE in perfused rat liver (22 ± 2.2 μg/g) and the value reported here, converted to wet tissue (200 ± 10 μg/g), gives an indication of the contribution of the included blood to the iron concentration in unperfused liver samples.

Lead was observed in over 80 per cent of all samples analyzed, though less frequently in brain and muscular tissues. The concentrations of this element in all tissues varied widely. The ranges of values reported here are approximately those reported by others.[2,3,4,6,7,20,23]

Magnesium showed the least variation from tissue to tissue of any element; that is, the median values for all tissues were close to the same value ($\sim$1 per cent). Except in intestine the variation from individual to individual was also relatively low. Our value for the concentration of this element in liver when converted to a basis of wet tissue (170 ± 5 μg/g) is in very good agreement with that of THIERS and VALLEE for perfused rat liver (160 ± 19 μg/g).

Manganese was found to have highest concentrations and greatest individual variation in liver, kidney and pancreas, the median values for the other tissues being less than half the median values for these three. The relatively small individual variation for most tissues reflects the existence of a control mechanism for manganese described by COTZIAS *et al.*[29]

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The value reported here for the concentration of manganese in liver, when converted to wet basis (1.7 ± 0.09 μg/g) compares very well with the value found by THIERS and VALLEE in perfused rat liver (1.3 ± 0.15 μg/g). In general the agreement between the values reported here and those reported by others[2,3,4,6,20,23,26] is good.

Molybdenum was observed in every sample of liver, in almost every sample of kidney and adrenal, and only occasionally in other tissues. The agreement between the values reported here for concentrations of this essential element in liver and kidney and those observed by others[2,3,6,7,22,23,26] is very good. BUTT *et al.*[2] and HARDING-BARLOW[4] have observed this element with great frequency in other tissues as well.

Nickel was observed in less than half of all samples analyzed, although it was observed in every tissue. The greatest frequency and the highest concentration occurred in skin. HARDING-BARLOW[4], with a lower limit of detection, found this element to occur in almost every sample. The concentrations she and KOCH *et al.*[7] observed are in the same range as those reported here while those of BUTT *et al.*[2] and TIETZ *et al.*[3] are much higher, although the latter groups did not detect this element in every sample.

Phosphorus was observed in concentrations of from 10–20 g per 100 g of ash in most tissues, only skin, aorta and thyroid showing a lower concentration. The variation about the mean for any one tissue was less for this element than for any other.

Potassium was also relatively constant from tissue to tissue, the highest values occurring in muscle, heart and spleen and the lowest in aorta, skin and thyroid. The mean value for potassium in liver reported here when calculated on the basis of wet tissue (2600 ± 52 μg/g), agrees very well with that observed by THIERS and VALLEE[5] in perfused rat liver (2900 ± 180 μg/g).

Silver was observed in about half of the samples of every tissue, generally in concentrations near the limits of detection. HARDING-BARLOW[4] observed about the same range of concentrations but a higher frequency of occurrence. BUTT *et al.*[2] found this element to occur in almost every sample and in much higher concentrations.

Strontium was observed in every sample of every tissue. The highest concentration and the greatest variability were observed in aorta and intestine. The range of concentrations observed is comparable with those reported by HARDING-BARLOW[4] and by SOWDEN[22] and those observed by KOIRTYOHANN and FELDMAN[23]. From the standpoint of ubiquity and constancy this element behaves like an essential element, perhaps because of its chemical similarity to the essential element calcium.

Tin was observed in about three fourths of all samples of every tissue except brain, where it was detected infrequently, and muscle, where it was observed in about one fifth of the samples. The range of values for this element is in good agreement with other observers.[3,4,7,20,23]

Titanium, like aluminum, was observed in highest concentrations in the lung and the skin. It was observed in almost every sample of these tissues, but in less than half of the samples of the other tissues. The range of concentrations in man reported here agree with the values reported for animals by SCHROEDER *et al.*[19] The values reported here are in good agreement with those observed by KOIRTYOHANN and FELDMAN.[23]

Vanadium was rarely observed except in about half of the samples of lung and about a sixth of the samples of intestine.

Zinc was observed in highest concentrations and with greatest individual variation in the prostate. Of the other tissues, the median value for kidney was highest, and brain and skin lowest, individual variation being relatively low for most tissues. The mean value for zinc in liver when converted to the wet basis (49 ± 1.4 μg/g) is almost three times as great as that reported by THIERS and VALLEE[5] for perfused rat tissue (17.4 ± 5.1). There is good agreement between the values reported here and those reported by others.[2,3,4,7,23,26,27]

Ash per cent of wet (100 × ash weight ÷ wet weight) and *Ash per cent of dry* (100 × ash weight ÷ dry weight) showed a normal distribution for many tissues but not for all. The aorta was the tissue for which the values varied most widely. In Table 1, in the column headed

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"Fraction observed", the numbers following "Ash per cent of wet" and "Ash per cent of dry" indicate the number of samples of a tissue for which values for these parameters were available divided by the total number of samples of the tissue which were analyzed.

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