Annual Progress Report

Contract AT(30-1)-952

Radium and Mesothorium Poisoning and Dosimetry and Instrumentation Techniques in Applied Radioactivity

THE WORK REPORTED HEREIN
IS SUPPORTED IN PART BY
THE U. S. ATOMIC ENERGY COMMISSION,
DIVISION OF BIOLOGY AND MEDICINE.

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DISCLAIMER

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Robley D. Evans
Professor of Physics
Project Leader

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A. Radium and Mesothorium Toxicity in Human Beings

The study of the toxicity of Ra and MsTh to humans has continued actively along the lines described in recent progress reports. In addition, several Thorotrast cases have been examined. The significant developments in this program are here described in turn.

1. Cases Studied

During the year physical and/or clinical studies have been made on a total of 151 persons of whom 132 are living and 19 are dead. In all cases possible (93) these persons have been brought to M.I.T. for a detailed examination including in most cases: γ-ray measurement of Rn and Tn decay products retained in body, α-ray measurement of Rn and Tn in breath, medical history, complete skeletal x-ray examination, urinalysis, blood cell counts (white-cell count, differential, hematocrit, sedimentation rate), and blood chemistry analysis (alkaline phosphatase, blood urea nitrogen, sugar, electrophoresis). For 35 living cases unable to come to M.I.T. preliminary physical data have been obtained through Rn analyses on breath collected in 1-liter flasks and shipped to M.I.T. The Ra burden is then calculated using the conversion factor that 1 $\mu\mu$c Rn/l in excess of room air is equivalent to 0.1 μc Ra in the body. This approximate conversion factor assumes 55 percent Rn exhalation and 6.5 l/min exhalation rate. No MsTh data have been obtained on these cases. Measurements were also made on bone and tooth samples from persons now dead or in a few cases still living. These analyses were made either by deemanation of radon and thoron or by γ-counting compared in each case against radium or thorium standards. From these measurements good MsTh/Ra ratios are available and approximate whole body burdens can be estimated. The detailed physical and clinical findings on all of these cases are included in Tables 3, 5-14 and the appendix.

2. Improvements in Technique of Physical Measurements

A significant improvement in the technique of the physical measurements has been brought about as a result of the transition in mid-year to an 8" x 4" crystal from the previously employed 4" x 4" crystal. The good resolution (about 8.5 percent on Cs^{137} γ, using conventional definition of full width at half peak height) and high total absorption fraction for high-energy γ rays have been valuable in two respects. First, the RaC γ ray of

energy 1.76 Mev is detected with considerably improved sensitivity, and of even greater importance, is completely resolved above the K^{40} γ ray at 1.46 Mev. Second, a notable increase in sensitivity for the 2.62-Mev ThC" γ ray has resulted. The quoted body RaC burden has been based on the 1.76-Mev line essentially exclusively. While calculations were in many cases carried out in addition for the 0.35-, 0.61-, and 1.12-Mev γ rays as a check, it has been felt that the freedom of the 1.76-Mev line from errors due to K^{40} and Cs^{137} γ radiation has given greater reliability to this value than is available from the others. Under conditions used, the counting statistical error in RaC burden (at negligible burden) is approximately 0.7×10^{-3} μc RaC. The quoted MsTh burden is based on the measurement of the ThC" 2.62-Mev γ, assuming secular equilibrium in the decay chain and a MsTh half-period of 6.7 years. Under conditions used the counting statistical error in the MsTh burden (at negligible burden) is approximately 3×10^{-4} μc MsTh.

The measurement and calibration procedures with the 8" x 4" crystal were analogous to those employed for the 4" x 4" crystal described in the 1959 annual progress report, with minor changes. The greater sensitivity of the large crystal made practical a shift in the basic calibration procedure from a 1-meter arc to a 1.25-meter arc, a geometry to which the body can much more easily be made to conform. The crystal position between the knees, previously used for maximum sensitivity on the lowest activity cases, was abandoned. Routine measurements were made with the crystal suspended over the seated subject approximately at the center of the arc of 50 cm radius formed by the rear surface (head to knees) of the subject's body. Measurement time has remained at 1 hour per subject.

3. Intercomparison of Ra Cases between ANL and M.I.T.

An extensive intercomparison of Ra burden measurements on living subjects has been carried out between M.I.T. and ANL. In all 11 cases a γ measurement comparison is possible for the Ra series, and in 1 case for the MsTh series. In 7 of the 11 cases comparison is possible on the breath Rn measurement. The results are included in Table 1.

4. Calibration of Fraction of Tn Exhaled in Ra-MsTh and in Thorotrast Cases

An important result of the improvement in sensitivity for detection of

Table 1. Summary of interlaboratory comparisons on Ra-MsTh burdens of living persons (1959-1960).

Table 1.

Summary of interlaboratory comparisons on Ra-MsTh burdens of living persons (1959 - 1960)

case no.	Argonne National Laboratory				M.I.T.			
	RaC (μc)	Rn (μc)	Total Ra (μc)	MsTh (μc)	RaC (μc)	Rn (μc)	Total Ra (μc)	MsTh (μc)
01-017	0.49	0.85	1.34	0.032	0.47	0.68	1.15	0.021
01-136	0.020	0.071	0.091	-	0.049 0.028 (remeasurement)	0.035	0.084	0.009 0.005
01-172	0.815	1.50	2.32	-	0.72	1.13	1.85	0.002 (breath)
01-208	0.342 (plus 2.6 Cs^{137})	0.93	1.27	-	0.47 0.42 (recalculation) (plus 2.6 Cs^{137})	0.82	1.29	0.000
03-003	0.224	0.363	0.587	-	0.235	0.415	0.65	-0.002
03-004	0.009 0.000 (remeasurement)	-	(0.028 est.)	-	-0.002	0.000	-0.002	0.0004
03-005	0.225	0.37	0.60	-	0.23	0.31	0.54	0.0005
03-006	0.204	-	(0.66 est.)	-	0.224	0.25	0.47	0.0004
09-001	0.004	-		-	0.004	0.003	0.007	-0.0002
09-002	0.008	-	0.028	-	0.003	0.007	0.010	-0.0002
09-003	0.155	0.232	0.387	-	0.164	0.25	0.41	0.0004

the ThC" 2.62-Mev γ ray was the ability to measure more directly and accurately in several additional living subjects the MsTh series burden against which to compare the exhaled Tn. Mesothorium burdens of living subjects in previous years could be estimated only from somewhat indirect γ measurements in the knee position or by measurements on exhaled Tn. Calculation of MsTh burden from breath Tn content required knowledge of the fraction of Tn exhaled, which could originally be determined only indirectly through the proportion $(MsTh/Ra)_{body} = (MsTh/Ra)_{tooth}$ for the few cases whose teeth had become available for laboratory Rn and Tn measurements.

Direct data on fractional Tn exhalation were obtained in 6 Ra-MsTh cases (01-017, 01-080, 01-084, 01-126, 01-136, 01-268) and in 7 Thorotrast cases (01-155, 01-202, 01-211, 01-212, 01-213, 01-286, 01-290). The average results were as follows:

nature of Th series burden	no. of cases	percent Tn exhaled
Ra-MsTh	6	0.12 (range 0.05-0.25)
Thorotrast	7	8 (range 3.6-12.3)

The result of about 0.1 percent Tn exhaled for MsTh cases agrees well with the previously calculated value. The value of about 8 percent for Thorotrast is consistent with the value of about 8 percent reported by Rundo, Ward, and Jensen.[1] It reflects an obvious difference in the localization of the ThX parent of Tn in the Thorotrast and MsTh cases.

5. Reliability of Teeth as Indicators of Total Body Ra Burden

The Ra burdens of many subjects for whom a significant medical history is available have been estimated only by measurements on the Ra content of one or more teeth. From comparisons of the approximate Ra/Ca ratios in the total body of a very few cases with the measured Ra/Ca ratio in their extracted teeth, it had previously been estimated that the ratio was about one half as great in the teeth as in the whole skeleton. More data have now become available on the relative concentration of Ra in teeth and total skeleton.

A total of 27 teeth from 5 individuals whose whole body Ra burden was reasonably accurately known were available for study. A few of these were dissolved in acid and assayed for both Rn and Tn by the customary deemanation techniques, and for Ca chemically. Most were assayed for Ra content by γ-

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1. J. Rundo, A. H. Ward, and P. G. Jensen, Phys. in Med. Biol. 3, 101 (1958).

counting after sealing in small plastic boxes. In these cases the Ca content of the tooth was assumed to be 29 percent of the gross tooth weight. Corrections to weight were estimated for small fillings. For larger fillings the teeth were broken apart and the fillings removed. In this manner the Ra/Ca ratios were estimated with an accuracy of perhaps ±25 percent, and compared against the whole body Ra/Ca ratio assuming a Ca content of 1000 g. Two or more different types of teeth were available for each of the 5 cases. Collectively virtually every type of tooth was represented, without obvious dependence of Ra/Ca ratio of tooth on type of tooth. In most cases the teeth had been extracted several years after exposure but several years before the whole body measurement. The comparative Ra/Ca ratios of teeth and total skeletons are summarized in Table 2.

Table 2. Comparative Ra/Ca ratio of teeth and skeleton

case number	age at exposure	number of teeth	$(Ra/Ca)_{tooth}$ average	$(Ra/Ca)_{skeleton}$ range
01-048	20	2	0.5	0.5 -0.6
01-002	16	2	0.29	0.24-0.34
01-017	43	6	0.55	0.29-0.73
01-049	16	6	0.18	0.10-0.26
01-016	28	11	0.25	0.15-0.38

From this table it can be seen that the average ratio $(Ra/Ca)_{tooth}/(Ra/Ca)_{skeleton}$ equals approximately 0.3, while the total spread on all 27 teeth covers the range 0.10-0.73 which is consistent with a standard deviation of 0.15, or 50 percent. Had one access to only 1 single tooth from among all these 27, his estimate of total skeleton Ra burden would in no case err by more than a factor of 3 if he assumed an average $(Ra/Ca)_{tooth}/(Ra/Ca)_{skeleton}$ value of 0.3. While this error is considerable if one is trying to draw toxicity conclusions from a single case, it is probably sufficiently small that statistical conclusions (e.g., tumor incidence as a function of body burden) drawn from a large population can be considered to have moderate reliability even if dosimetry is based only on single tooth assays.

Complete details of tooth and bone measurements on 24 individuals are given in Table 3.

Table 3. A summary of MsTh/Ra ratios (at date of last exposure or 1926) and of estimated whole body Ra burdens based on recent measurements of bone and tooth samples. In column 11 the body burden of Ra has been estimated from the sample. It has been assumed that the ratio Ra/Ca in a bone fragment equals that in the total body, while the same ratio in a tooth equals 1/3 that in the total body. In a few cases a "measured" total body burden is given in column 12 based on whole body analysis of modest accuracy made (usually) many years ago. Column 13 gives the ratio of the estimate based on tooth or bone samples to the total body burden for those persons whose total body burden was actually measured during life, or following exhumation.

Table 3.

Analysis of bone and tooth samples

case no., yr. of birth	exposure, type and date	sample no.	description	gross wt. sample (g)	Ca content * (g)	Ca ** (% of wt.)	method of activity determination	MsTh/Ra *** in 1926 or last exposure (μc/μc)	meas. μcRa/10^3gCa	body burden Ra est. from sample (μc)	meas. body burden Ra (μc)	meas. μcRa/10^3g Ca / meas. μcRa in body: average
01-002 1906	dial painter 1922-1936	44a	tooth, maxillary 1st premolar buccolingual, hemisection	0.515	0.127	25	α	0.04	7.6	23	18	0.42
		44b	tooth, maxillary 1st premolar buccolingual, hemisection	0.134	(0.039)	(29)	γ 2" crystal	-	0.82	2.5	18	0.05 > 0.24
		45	tooth, maxillary rt. 2nd premolar	0.755	(0.22)	(29)	γ 2" crystal	-	4.4	13	18	0.24
01-007 1886	Ra injections 1926	3a	ulna	0.238 (ash)	0.054	23	α	0.007	9.6	9.6	8 - 9	1.01
01-008 1901	dial painter 1917-1918	587, 590, 601 - 605	humerus, skull, ribs, lumbar vertebra, lt. femur	1350	(16)	(12)	γ 8" crystal	0.06 ± 0.02	5.1	5	6 - 8	0.73
		587	rt. humerus	315	(38)	(12)	γ 8" crystal	-	4.5	4.5	6 - 8	0 64
		601 x	lt. femur	732	(88)	(12)	γ 8" crystal	-	5.8	6	6 - 8	0.83
		602 xx	skull	6.7	(0.80)	(12)	γ 8" crystal	-	10	10	6 - 8	1.43 > 0.85
		603 +	rib	34	(4.1)	(12)	γ 8" crystal	-	5.8	6	6 - 8	0.83
		604 ++	vertebra	76	(9.1)	(12)	γ 8" crystal	-	8.4	8.4	6 - 8	1.20
		605 †	sternum	180	(22)	(12)	γ 8" crystal	-	1.8	1.8	6 - 8	0.26
01-014 1901	dial painter 1916-1919	5	femur, lower rt.	36.9	(8.5)	(23)	γ 8" crystal	0.07 ± 0.04	3.2	3	3	1.07
01-292 ~1903	dial painter 1919-1922	132a	bone, unidentified	1.33 (ash)	0.53	40	α	1.3	1.7	1.7	-	
		132b	bone, ashed	1.43	(0.49)	(34)	γ 2" crystal	-	2.2	2.2	-	
		133	bone, ashed	3.59	(1.2)	(34)	γ 2" crystal	-	3.0	3.0	-	
		141	bone, ashed	5.56	(1.9)	(34)	γ 2" crystal	-	6.3	6.3	-	
		163	bone, ashed	4.06	(1.38)	(34)	γ 2" crystal	-	1.2	1.2	-	
		164	bone	2.57	(0.59)	(23)	γ 2" crystal	-	3.2	3.2	-	
		165	bone, ashed	2.47	(0.84)	(34)	γ 2" crystal	-	2.6	2.6	-	

* figure in ( ) is an estimated value

** method of Ca estimation by chemical determination [modification of Solomon, Gabrio, and Smith, Arch. Biochem. 11, 433 (1946)] or if in ( ) by estimation

*** based on 6.7 yr. half-period of MsTh

x New Jersey spec. 48-B1

xx New Jersey spec. 48-B4

\+ New Jersey spec. 48-B5

++ New Jersey spec. 48-B7

† New Jersey spec. 48-B8

Table 3 (continued)

case no., yr. of birth	exposure, type and date	sample no.	description	gross wt. sample (g)	Ca content * (g)	Ca ** (% of wt.)	method of activity determination	MsTh/Ra *** in 1926 or last exposure (μc/μc)	meas. μcRa/10^3gCa	body burden Ra est. from sample (μc)	meas. body burden Ra (μc)	meas. μcRa/10^3g Ca / meas. μcRa in body — average
01-009 1897	dial painter 1918-1919	18a	tibia, midsection	2.43 (ash)	0.94	39	α	0 04	2.8	2.8	~7	0.40
01-016 1893	dial painter 1921-1925	123	bone fragments	0.29	(0.067)	(23)	γ 2" crystal	-	3.0	3.0	2.5	1.20
		174a	tooth, maxillary 2nd premolar buccolingual, hemisection	0.571	0.18	32	α	0.44	0.47	1.4	2.5	0.19
		174b	tooth, maxillary 2nd premolar buccolingual, hemisection	0.536	(0.155)	(29)	γ 2" crystal	-	0.59	1.8	2.5	0.24
		175	tooth, maxillary lt. 2nd premolar	1.29	(0.35)	(29)	γ 2" crystal	-	0.37	1.1	2.5	0.15
		176	tooth, maxillary lt. central incisor	1.115	(0.32)	(29)	γ 2" crystal	-	0.80	2.4	2.5	0.32
		177	tooth, maxillary rt. 2nd molar	2.66	(0.74)	(29)	γ 2" crystal	-	0.48	1.4	2.5	0.19
		178	tooth, mandibular rt. 1st premolar	1.185	(0.34)	(29)	γ 2" crystal	-	0.69	2.1	2.5	0.28
		179	tooth, mandibular lt. 1st premolar	0.972	(0.28)	(29)	γ 2" crystal	-	0.62	1.9	2.5	0.25
		180	tooth, mandibular rt. canine	1.134	(0.33)	(29)	γ 2" crystal	-	0.60	1.8	2.5	0.24
		181	tooth, mandibular lt. canine	1.111	(0.32)	(29)	γ 2" crystal	-	0.54	1.6	2.5	0.22
		182a	tooth, molar	2.24	(0.61)	(29)	γ 2" crystal	-	0.77	2.3	2.5	0.31
		182b	alveolar bone from roots of spec. No. 182a	0.51	(0.12)	(23)	γ 2" crystal	-	8.3	8.3	2.5	3.32
		183a	tooth, molar	2.64	(0.76)	(29)	γ 2" crystal	-	0.58	1.7	2.5	0.23
		183b	alveolar bone from roots of spec. No. 183a	0.28	(0.064)	(23)	γ 2" crystal	-	5.4	5.4	2.5	2.16
		184	mandible	0.80	(0.16)	(20)	γ 2" crystal	-	0.63	0.6	2.5	0.25
		186	tooth, maxillary central rt. incisor	1.21	(0.35)	(29)	γ 2" crystal	-	0.95	2.8	2.5	0.38
(I. Ja.) 1905	dial painter 1924-1927	540a	radius	1.52 (ash)	0.58	38	α	0.02	2.0	2	-	
01-017 1883	drank Radithor 1926-1929	105a	tooth, mandibular rt. canine buccolingual, hemisection	0.275	0.085	31	α	0.45	0.25	0.75	1.15	0.22
		105b	tooth, mandibular rt. canine buccolingual, hemisection	0.506	(0.147)	(29)	γ 8" crystal	-	0.38	1.1	1.15	0.10
		106	tooth, mandibular rt. central incisor	0.634	(0.184)	(29)	γ 8" crystal	-	0.68	2.0	1.15	0.59
		107	tooth, root only	0.173	(0.050)	(29)	γ 8" crystal	-	0.84	2.5	1.15	0.73
		109	tooth, mandibular lt. central incisor	0.519	(0.150)	(29)	γ 8" crystal	-	0.62	1.9	1.15	0.54
		110	tooth, mandibular rt. lateral incisor	0.545	(0.158)	(29)	γ 8" crystal	-	0.65	2.0	1.15	0.57
		111	tooth, mandibular lt. lateral incisor	0.637	(0.185)	(29)	γ 8" crystal	-	0.63	1.9	1.15	0.55

0.62

0.47

* figure in ( ) is an estimated value

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*** based on 6.7 yr half-period of MsTh

Table 3 (continued)

case no., yr. of birth	exposure, type and date	sample no.	description	gross wt. sample (g)	Ca content * (g)	Ca ** (% of wt.)	method of activity determination	MsTh/Ra *** in 1926 or last exposure (μc/μc)	meas. μcRa/10^3gCa	body burden Ra est. from sample (μc)	meas. body burden Ra (μc)	meas. μcRa/10^3g Ca / meas. μcRa in body: average
01-054 ~1908	dial painter 1924-1928	62a	tooth, mandibular rt. incisor buccolingual, hemisection	0.252	(0.073) o	(29)	α	2.5	0.53	1.6	-	
		62b	tooth, mandibular lt. lateral incisor	0.559	(0.16)	(29)	γ 2" crystal	-	0.56	1.7	-	
01-052 1910	dial painter 1924-1927	61a	tooth, maxillary rt. central incisor, hemisection	0.374	0.124	33	α	2.0	0.55	1.6	-	
		61b	tooth, maxillary rt. central incisor, hemisection	0.65	(0.19)	(29)	γ 2" crystal	-	0.54	1.6	-	
(I. Da.) 1906	dial painter 1922	479a	femur	1.03 (ash)	0.39	38	α	0.23	1.6	1.6	-	
01-149 1888	dial painter 1919-1920	598	femur x	758	(91)	(12)	γ 8" crystal	0.9 ± 0.2	1.76	1.76	1.3	1.35
		599	rib xx	16	(1.9)	(12)	γ 8" crystal	-	1.1	1.1	1.3	0.85 → 1.97
		600	skull fragment +	5.3	(0.64)	(12)	γ 8" crystal	-	4.8	5	1.3	3.7
01-032 1908	dial painter 1924-1928	31	tooth fragment, mandibular lat. incisor, buccolingual	0.253	(0.073) ++	(29)	α	2.6	0.47	1.4	-	
01-049 1903	dial painter 1920	58b	tooth, mandibular 2nd molar buccolingual, hemisection	0.800	(0.23)	(29)	γ 2" crystal	-	0.24	0.7	1.0 ± 0.2 †	0.24
		59	teeth, max. lt. 2nd premolar, mandibular lt. lat. incisor	1.66	(0.35)	(29)	γ 2" crystal	-	0.21	0.6	1.0 ± 0.2 †	0.21
		597, 620-750	total skeleton	4600	(1060)	(23)	γ 8" crystal	4.9	-	-	1.0 ± 0.2 †	-
		622-628, 632-643, 677-681	all vertebrae	472	(108)	(23)	γ 8" crystal	4.3	2.3	2.3	1.0 ± 0.2 †	2.3
		685	rt. femur	440	(100)	(23)	γ 8" crystal	4.1	0.84	0.8	1.0 ± 0.2 †	0.84 → 0.47
		695	tooth, unidentified molar, lt. mandible	1.23	(0.36)	(29)	γ 2" crystal	-	0.19	0.6	1.0 ± 0.2 †	0.19
		696	tooth, unidentified molar, rt. mandible	1.33	(0.32)	(29)	γ 2" crystal	-	0.10	0.30	1.0 ± 0.2 †	0.1
		697	tooth, unidentified	1.45	(0.36)	(29)	γ 2" crystal	-	0.10	0.3	1.0 ± 0.2 †	0.10
		753	tooth, incisor, lt. maxilla	1.08	(0.31)	(29)	γ 2" crystal	-	0.26	0.8	1.0 ± 0.2 †	0.26
01-079 1901	dial painter 1920-1924 1929-1943	120a	tooth, maxillary premolar buccolingual, hemisection	0.30	0.064	21	α	9	0.020	0.06	-	
		120b	tooth, probably premolar	0.082	(0.024)	(29)	γ 2" crystal	-	0.15 ± 0.1	0.5 ± 0.3	-	
		121	tooth, mandibular rt. 1st or 2nd molar	1.21	(0.35)	(29)	γ 2" crystal	-	0.26	0.8	-	

* figure in ( ) is an estimated value

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*** based on 6.7 yr. half-period of MsTh

o chemical analysis available, but unreasonably low

x New Jersey spec. 47-B1

xx New Jersey spec. 47-B3

\+ New Jersey spec. 47-B5

++ chemical analysis available, but unreasonably high

† cadaver measurement

Table 3 (continued)

case no., yr. of birth	exposure, type and date	sample no.	description	gross wt. sample (g)	Ca content * (g)	Ca ** (% of wt.)	method of activity determination	MsTh/Ra *** in 1926 or last exposure (μc/μc)	meas. μcRa/10^3gCa	body burden Ra est. from sample (μc)	meas. body burden Ra (μc)	meas. μcRa/10^3g Ca / meas. μcRa in body — average
01-046 1903	dial painter 1920-1923	48a	tooth, maxillary rt. 1st molar buccolingual, hemisection	0.587	0.167	28	α	3.9	0.092	0.27	-	
		48b	tooth, maxillary rt. 1st molar buccolingual, hemisection	0.485	(0.12)	(29)	γ 2" crystal	-	0.17	0.5	-	
		49	tooth, maxillary rt. central incisor, fragment of alveolar bone attached	0.827	(0.23)	(29)	γ 2" crystal	-	0.22	0.7	-	
01-027 1889	chemist 1912-1932	561-571, 583, 591-596, 609-616	total cremation ash	1730	(470)	(34)	γ 4" crystal	-	0.51	0.51	0.3 - 0.5	1.28
		568-571 611	bone, ash, probably skull and pelvis	12.6	(4.3)	(34)	γ 2" crystal	-	0.0006	0.0006	0.3 - 0.5	0.0015
		562	bone, ash	3.88	(1.32)	(34)	γ 2" crystal	-	0.27	0.27	0.3 - 0.5	0.68
		563	bone, ash	3.36	(1.14)	(34)	γ 2" crystal	-	0.38	0.38	0.3 - 0.5	0.95
		564	bone, ash	2.78	(0.95)	(34)	γ 2" crystal	-	0.31	0.31	0.3 - 0.5	0.78
		565	bone, ash	3.34	(1.14)	(34)	γ 2" crystal	-	0.46	0.46	0.3 - 0.5	1.15
		566	bone, ash, probably pelvis	3.22	(0.38)	(34)	γ 2" crystal	-	0.39	0.39	0.3 - 0.5	0.98
		567	bone, ash	3.72	(1.26)	(34)	γ 2" crystal	-	0.68	0.68	0.3 - 0.5	1.70
		609	bone, ash, probably rib	2.14	(0.73)	(34)	γ 2" crystal	-	0.45	0.45	0.3 - 0.5	1.13
		610	bone, ash, probably vertebra	2.54	(0.86)	(34)	γ 2" crystal	-	0.53	0.53	0.3 - 0.5	1.33
		612	bone, ash, probably femur	4.84	(1.65)	(34)	γ 2" crystal	-	0.41	0.41	0.3 - 0.5	1.03
		613	bone, ash, probably femur	1.50	(0.51)	(34)	γ 2" crystal	-	0.82	0.82	0.3 - 0.5	2.05
												1.09
01-087 1905	dial painter 1921-1928	56	tooth, mandibular rt. 3rd molar	1.15	(0.33)	(29)	γ 2" crystal	-	0.27	0.8	-	
		124a	tooth, mandibular premolar buccolingual, hemisection	0.405	0.127	31	α	2.3	0.14	0.42	-	
		124b	tooth, mandibular premolar buccolingual, hemisection	0.415	(0.12)	(29)	γ 2" crystal	-	0.033	0.10	-	
		126	tooth, probably 1st lower rt. premolar	0.378	(0.11)	(29)	γ 2" crystal	-	0.12	0.36	-	
01-023 1907	dial painter 1924-1950	525a	bone, probably ulna	0.961 (ash)	0.38	40	α	0.03	0.41	0.4	~1	0.41
01-132 1908	dial painter 1923-1925	166a	tooth, maxillary 2nd molar	1.65	0.40	24	α	3.8	0.20	0.6	-	
		166b	tooth, maxillary 2nd molar, longitudinal section, 1/2 tooth	0.324	(0.094)	(29)	γ 2" crystal	-	0.13	0.4	-	
		167	tooth, probably maxillary lt. 3rd molar	1.14	(0.33)	(29)	γ 2" crystal	-	0.079	0.24	-	

* figure in ( ) is an estimated value

** method of Ca estimation by chemical determination [modification of Solomon, Gabrio, and Smith, Arch. Biochem. 11, 433 (1946)] or if in ( ) by estimation

*** based on 6.7 yr. half-period of MsTh

Table 3 (continued)

case no., yr. of birth	exposure; type and date	sample no.	description	gross wt. sample (g)	Ca content * (g)	Ca ** (% of wt.)	method of activity determination	MsTh/Ra *** in 1926 or last exposure (μc/μc)	meas. μcRa/10^3gCa	body burden Ra est. from sample (μc)	meas. body burden Ra (μc)	meas. μcRa/10^3g Ca / meas. μcRa in body — average
01-115 1908	dial painter 1924-1930	144a	tooth, mandibular canine buccolingual, hemisection	0.322	0.12	37	α	2.8	0.042	0.12	-	
		145	tooth, mandibular rt. 2nd premolar	0.789	(0.23)	(29)	γ 2" crystal	-	0.15	0.45	-	
		146	tooth, maxillary rt. canine	0.874	(0.25)	(29)	γ 2" crystal	-	0.18	0.5	-	
		147	tooth, maxillary lt. 2nd premolar	0.90	(0.17)	(29)	γ 2" crystal	-	0.25	0.75	-	
		148	tooth, mandibular lt. central incisor	0.645	(0.19)	(29)	γ 2" crystal	-	0.024	0.07 ± 0.04	-	
01-048 1900	dial painter 1920-1927	51a	tooth, maxillary rt. lateral buccolingual, hemisection	0.281	0.096	34	α	2.3	0.058 ± 0.006	0.17	0.14	0.41
		51b	tooth, maxillary rt. lateral buccolingual, hemisection	0.299	(0.087)	(29)	γ 2" crystal	-	0.10 ± 0.04	0.3	0.14	0.71 → 0.56
		52	tooth, mandibular central rt. incisor	0.658	(0.19)	(29)	γ 2" crystal	-	0.08 ± 0.02	0.24	0.14	0.57
01-112 1908	dial painter 1924-1930	138, 139b 140,143	bone fragments	5.30	(1.22)	(23)	γ 8" crystal	-	0.035	0.035	-	
		309	tooth, probably molar	1.50	0.49	33	α	2.5	0.041	0.12	-	

* figure in ( ) is an estimated value

** method of Ca estimation by chemical determination [modification of Solomon, Gabrio, and Smith, Arch. Biochem. 11, 433 (1946)] or if in ( ) by estimation

*** based on 6.7 yr. half-period of MsTh

6. MsTh/Ra Ratio of Waterbury Dial Painters

The largest single group of cases available to this laboratory (Waterbury cases) is known to have been exposed to larger quantities of MsTh than of Ra. However, the MsTh has decayed so far that it can now be measured only in a comparatively few higher level cases. The Ra, having a longer half-period, can on the other hand be more readily detected. An important problem in the dosimetry has been to measure the MsTh/Ra ratio of as many cases as possible, and to estimate how reliably this average ratio can be applied to other cases in which it is not directly measurable. The acquisition of good MsTh/Ra data on several additional living cases, and a careful reanalysis of most of the bone and tooth fragments from this population has given a clearer, and happily, a fairly simple picture of this important question.

A total of 15 cases from this group having well-established MsTh/Ra ratios is available. Assuming a MsTh half-period of 6.7 years, and extrapolating all cases back to a representative date of 1924 (actual exposure to MsTh occurred 1920-1926), one finds MsTh/Ra activity ratios in 1924 of:

average	3.4
range	2.5-4.8

The spread among these figures is sufficiently small that, aside from a possible error in the MsTh half-period, the MsTh/Ra ratio of the paint ingested by this group of cases can be considered rather well established. In no case out of 15 does this ratio deviate from the mean by more than 35 percent of the mean.

7. MsTh/Ra Ratio of Other Dial Painters

Over the years a number of cases exposed at another company have been studied at M.I.T. Teeth and bone fragments have recently been reanalyzed, and recent data on living cases reviewed, to find the MsTh/Ra ratio in the paint to which these cases were exposed (assuming a MsTh half-period of 6.7 years). Eight reasonably reliable measurements are available, with results not entirely consistent. The breakdown according to date of employment is given in Table 4. Extrapolation has been made to year of last exposure.

Table 4. MsTh/Ra activity ratio of other dial painters

subject	exposure period	MsTh/Ra activity ratio
01-183	1915-1917	<0.2
01-268	1916,1918	2.1
01-008	1917-1918	0.06
01-014	1916-1919	0.07
01-009	1918-1919	0.04
01-172	1918-1920	0.06
01-149	1919-1920	0.9
01-292	1919-1922	1.3

Should it happen that case 01-268 was actually exposed at a later date (for which there is now no evidence) the results would be consistent with an introduction of MsTh into the paint in about 1920. According to incomplete company records available to us,* MsTh was apparently introduced sometime between 1917 and 1919. This possibility is also consistent with the finding of MsTh/Ra activity ratios of <0.05 in 12 old dial paint samples which probably, although not certainly, originated with this company. Regardless of the uncertainty in dates, it is clear that both predominantly Ra and predominantly MsTh cases are to be found among employees of this company. This is an important point to establish in that this pool of cases may well be the largest.

8. Ambiguity as to Half-period of MsTh

The half-period of MsTh (Ra^{228}), heretofore assumed to be 6.7 years, has recently been called into question by C. W. Mays, University of Utah, who found a somewhat lower value to be more consistent with his data. Measurements have been made at this laboratory with the result of 5.7 ± 0.2 years. The method is discussed briefly in Sec. B7 of this report.

The significance of a reduced MsTh half-period is that it would raise the calculated initial MsTh/Ra ratios, and thereby the cumulative radiation dose attributable to MsTh as compared to Ra. While the details depend upon the period of extrapolation, relative significance of cumulative rads or rad-years, etc., the approximate effect of a reduction from 6.7 to 5.7 years

* Personal communication from Mr. C. W. Wallhausen, 14 March 1950.

in the MsTh half-period would be to make the importance of MsTh relative to Ra about 50 percent greater for our cases than previously estimated. For example, if one assumed a 5.7-year rather than 6.7-year half-period, the average MsTh/Ra activity ratio of the Waterbury cases as of 1924 would have been 6.3 instead of 3.4 as previously calculated. However, the number of μc of MsTh estimated to be necessary to give the same cumulative rads over the next 36 years as 1 μc of Ra would rise from a value of about 0.6 μc to a value of about 0.7 μc. The over-all effect is the approximately 50 percent greater importance of MsTh relative to Ra than previously estimated.

9. Results of Ra and MsTh Measurements

The data obtained on the Ra and MsTh burdens are collected in Tables 5-10 for those subjects studied either at M.I.T. or by our laboratory staff at the subject's place of residence. The data obtained on Ra burdens by means of one breath flask only are collected in Table 11, and by means of two or more breath flasks only in Table 12.

In certain cases, particularly the low activity subjects, the Rn and γ results are not entirely consistent. Where this has been the case, a total Ra value has been established based on a weighted judgment as to the reliability of the two separate values. The quoted error in such conditions has been made large enough to cover the alternative possibilities as to error.

In Tables 5-10 the successive columns give the following information:

col. 3: "Ra equivalent by γ". The μc of Ra in equilibrium with the RaB and RaC measured in the body by γ rays.

col. 4: "Ra equivalent by Rn". The μc of Ra in equilibrium with the Rn calculated to be outside the patient's body as a result of exhalation.

col. 7: Tn exhalation is assumed to be 0.1 percent.

col. 8: "Best measurement of 1960 MsTh". The value in either column 6 or 7 which is considered more accurate.

col. 9 : "MsTh/Ra at last exposure". 1960 value extrapolated to date of last exposure, assuming 6.7-year MsTh half-period. For dial painters, extrapolation is to 1926 if exposure continued after 1926, since use of MsTh declined after 1926.

In these same Tables 5-10, the listed errors purport to give the standard deviation of the quoted value, as follows:

col. 3: all errors included.

col. 4: all errors included for 1-hour sampling period, but no error included for possible deviation of this 1-hour period from average condition.

col. 5: mathematically propagated error from columns 3 and 4.

col. 6: error includes counting statistics only. Other errors perhaps of such magnitude that correct value lies within range of 0.5 to 2 times result given.

col. 7: error includes counting statistics only. Other errors perhaps of magnitude such that correct value lies within range of approximately 0.3 to 3 times result given.

col. 8: same error as column 6 or 7.

col. 9: mathematically propagated error from columns 5 and 8.

In Table 11 the reported values are preceded by a "less than" sign, indicating that at least a part of the measured value is attributable to room air Rn content, not to subject's Ra burden.

In Table 12 indicated errors are calculated from scatter of replications, or counting statistics, whichever is larger. These errors should be considered only as lower limits to the standard deviation of the reported result.

Table 5. All subjects included in this table are living persons formerly employed as dial painters at the Waterbury Clock Company and/or the New England Watch Company. For information on the column headings and the listed errors see section A9 (pp. 15-16) of this report.

Table 5.

Dial painters

Waterbury Clock Co. and New England Watch Co.

case no., year of birth	exposure period	Ra equivalent by γ (μc)	Ra equivalent by Rn (μc)	Total Ra (= γ + Rn) (μc)	1960 MsTh by γ (μc)	1960 MsTh by Tn (μc)	best measurement of 1960 MsTh (μc)	MsTh/Ra in 1926 or last exposure if earlier (μc/μc)
01-126 1903	6 Feb. 1922 - 1931	0.061 ± 0.003	0.127 ± 0.003	0.188 ± 0.005	$(13.9 \pm 0.6) \times 10^{-3}$	$(17 \pm 2) \times 10^{-3}$	$(13.9 \pm 0.6) \times 10^{-3}$	2.5 ± 0.2
01-080 1902	31 Jan. 1921 - 29 Jan. 1923 8 Feb. 1923 - 2 Jan. 1924	0.034 ± 0.002	0.049 x	0.083 x	$(8.3 \pm 0.3) \times 10^{-3}$	$(7.5 \pm 1) \times 10^{-3}$	$(8.3 \pm 0.3) \times 10^{-3}$	4.5 ± 0.2
01-084 1904	24 Sep. 1923 - ~ 1931	0.029 ± 0.002	0.039 ± 0.003	0.068 ± 0.004	$(5.6 \pm 0.3) \times 10^{-3}$	$(14 \pm 1) \times 10^{-3}$	$(5.6 \pm 0.3) \times 10^{-3}$	2.8
01-136 1907	9 July 1923 - 3 Feb. 1927	0.028 ± 0.002	0.035 ± 0.002 xx	0.063 ± 0.003	$(5.0 \pm 0.3) \times 10^{-3}$	$(2.6 \pm 0.7) \times 10^{-3}$	$(5.0 \pm 0.3) \times 10^{-3}$	2.4 ± 0.2
01-096 1909	~ 6 yrs., 21 Feb. 1927 - 26 May 1936	-	0.015 ± 0.002	0.027 ± 0.004 *	-	-	-	-
01-201 1911	22 Oct. 1925 - 11 Oct. 1926; 10 Jan. 1927 - 17 Feb. 1927	0.012 ± 0.002	0.014 ± 0.001	0.026 ± 0.002	$(-0.4 \pm 0.6) \times 10^{-3}$	$(-0.5 \pm 0.7) \times 10^{-3}$	$(-0.4 \pm 0.6) \times 10^{-3}$	indeterminate
01-297 1901	7 Jan. 1921 - 20 Oct. 1921; 15 Oct. 1923 - 5 Nov. 1923	0.007 ± 0.001	0.009 ± 0.002	0.016 ± 0.002	$(1.6 \pm 0.2) \times 10^{-3}$	$(2.3 \pm 0.5) \times 10^{-3}$	$(1.6 \pm 0.2) \times 10^{-3}$	4.5 ± 1
01-095 1907	11 July 1922; 29 Jan. 1923 - 19 Mar. 1923	0.0037 ± 0.0004	0.005 ± 0.001	0.0087 ± 0.002	$(0.1 \pm 0.7) \times 10^{-3}$	$(1.3 \pm 0.6) \times 10^{-3}$	$(0.1 \pm 0.7) \times 10^{-3}$ *	indeterminate
01-038 1910	3 Feb. 1927 - 22 Mar. 1929	0.004 ± 0.001	0.004 ± 0.001	0.008 ± 0.002	$(-0.3 \pm 0.6) \times 10^{-3}$	$(-0.4 \pm 0.6) \times 10^{-3}$	$(-0.3 \pm 0.6) \times 10^{-3}$	indeterminate
01-229 1903	28 Aug. 1923 - 12 Sep. 1923	0.0048 ± 0.0006	0.003 ± 0.001	0.008 ± 0.002	$(0.1 \pm 0.5) \times 10^{-3}$	$(2 \pm 0.7) \times 10^{-3}$	$(0.1 \pm 0.5) \times 10^{-3}$	indeterminate
01-081 1907	5 Jan. 1923 - 26 Jan. 1923; 12 Feb. 1923 - 9 Apr. 1923	0.0019 ± 0.0004	0.010 ± 0.005	0.007 ± 0.005	$(0.9 \pm 0.6) \times 10^{-3}$	$(-0.2 \pm 0.5) \times 10^{-3}$	$(0.9 \pm 0.6) \times 10^{-3}$	indeterminate
01-055 1907	19 Feb. 1925 - 31 Mar. 1925; 8 Sep. 1925 - 14 Oct. 1926	0.0016 ± 0.0010	0.005 ± 0.001	0.006 ± 0.002	$(-0.4 \pm 0.5) \times 10^{-3}$	$(0.6 \pm 0.5) \times 10^{-3}$	$(-0.4 \pm 0.5) \times 10^{-3}$	indeterminate
01-289 1899	11 July 1919 - 24 Jan. 1921	0.0018 ± 0.0005	0.0045 ± 0.001	0.006 ± 0.002	$(-0.2 \pm 0.2) \times 10^{-3}$	-	$(-0.2 \pm 0.2) \times 10^{-3}$	indeterminate
01-209 1908	13 Sep. 1926 - 8 Nov. 1926; 13 Dec. 1926 - 9 Feb. 1927	-0.0008 ± 0.0005	0.007 ± 0.001	0.006 ± 0.001	$(-0.4 \pm 0.6) \times 10^{-3}$	$(0.3 \pm 0.6) \times 10^{-3}$	$(-0.4 \pm 0.6) \times 10^{-3}$	indeterminate

x Rn measurement 27 June 1957; error not well known

xx Rn measurement 2 April 1959

* based on Rn only

Table 5 (continued)

case no., year of birth	exposure period	Ra equivalent by γ (μc)	Ra equivalent by Rn (μc)	Total Ra (= γ + Rn) (μc)	1960 MsTh by γ (μc)	1960 MsTh by Tn (μc)	best measurement of 1960 MsTh (μc)	MsTh/Ra in 1926 or last exposure if earlier (μc/μc)
01-287 1908	22 May 1927 - 14 June 1928	0.003 ± 0.002	-	0.005 ± 0.004 *	$(-0.2 \pm 0.3) \times 10^{-3}$	-	$(-0.2 \pm 0.3) \times 10^{-3}$	indeterminate
01-291 1910	24 July 1928 - 26 Nov. 1928	0.0009 ± 0.0005	0.0043 ± 0.0014	0.005 ± 0.002	$(0.5 \pm 0.2) \times 10^{-3}$	-	$(0.5 \pm 0.2) \times 10^{-3}$	indeterminate
01-093 1904	26 Feb. 1926 - 22 Apr. 1926	0.0003 ± 0.0005	0.006 ± 0.002	0.004 ± 0.004	$(-0.2 \pm 0.6) \times 10^{-3}$	$(-0.7 \pm 0.5) \times 10^{-3}$	$(-0.2 \pm 0.6) \times 10^{-3}$	indeterminate
01-285 1900	17 Sep. 1923 - 22 Sep. 1923	-0.0005 ± 0.0005	0.005 ± 0.001	0 004 ± 0.003	$(-0.4 \pm 0.2) \times 10^{-3}$	-	$(-0.4 \pm 0.2) \times 10^{-3}$	indeterminate
01-041 1909	23 May 1927 - 25 Oct. 1927	0.0003 ± 0.001	0.004 ± 0.002	0.004 ± 0.002	$(0.3 \pm 0.7) \times 10^{-3}$	$(-0.5 \pm 0.6) \times 10^{-3}$	$(0.3 \pm 0.7) \times 10^{-3}$	indeterminate
01-039 1913	2 Apr. 1934 - 8 Mar. 1937	0.0005 ± 0.0009	0.003 ± 0.001	0.004 ± 0.001	$(1.0 \pm 0.6) \times 10^{-3}$	$(0.7 \pm 0.6) \times 10^{-3}$	$(1 \pm 0.6) \times 10^{-3}$	indeterminate
01-207 1909	3 Mar. 1927 - 4 May 1927	0.0021 ± 0.0006	0.0024 ± 0.001	0.004 ± 0.001	$(-0.3 \pm 0.6) \times 10^{-3}$	$(0.4 \pm 0.5) \times 10^{-3}$	$(-0.3 \pm 0.6) \times 10^{-3}$	indeterminate
01-050 1911	12 Oct. 1925 - 19 Dec. 1925	0.0014 ± 0.001	0.002 ± 0.001	0.003 ± 0.002	$(0.07 \pm 0.4) \times 10^{-3}$	$(0.9 \pm 0.9) \times 10^{-3}$	$(0.07 \pm 0.4) \times 10^{-3}$	indeterminate
01-113 1912	25 July 1928 - 1 Sep. 1928	-0.001 ± 0.001	0.004 ± 0.001	0.003 ± 0.002	$(-0.3 \pm 0.6) \times 10^{-3}$	$(0.3 \pm 0.6) \times 10^{-3}$	$(0.3 \pm 0.6) \times 10^{-3}$	indeterminate
01-265 1902	23 Nov. 1919 - 30 Nov. 1920	-0.001 ± 0.001	0.004 ± 0.001	0.003 ± 0.002	$(-0.2 \pm 0.7) \times 10^{-3}$	$(0.4 \pm 0.6) \times 10^{-3}$	$(-0.2 \pm 0.7) \times 10^{-3}$	indeterminate
01-294 1912	1 July 1927 - 2 Aug. 1928	-0.0002 + 0.0006	0.003 ± 0 002	0.003 ± 0.002	$(0.1 \pm 0.2) \times 10^{-3}$	-	$(0.1 \pm 0.2) \times 10^{-3}$	indeterminate
01-227 1908	> 1930	-0.001 ± 0.001	0.003 ± 0.001	0.002 ± 0.002	$(-0.6 \pm 0.6) \times 10^{-3}$	$(1.8 \pm 0.6) \times 10^{-3}$	$(-0.6 \pm 0.6) \times 10^{-3}$	indeterminate
01-288 1896	4 Apr. 1926 - 16 Aug. 1926	0.001 ± 0.001	-	0.002 ± 0.002	$(0.5 \pm 0.3) \times 10^{-3}$	-	$(0.5 \pm 0.3) \times 10^{-3}$	indeterminate
01-125 1911	27 Oct. 1927 - 8 Dec. 1927	0.0003 ± 0.0006	0.002 ± 0.001	0.002 ± 0.001	$(-0.9 \pm 0.6) \times 10^{-3}$	$(-0.4 \pm 0.6) \times 10^{-3}$	$(-0.9 \pm 0.6) \times 10^{-3}$	indeterminate
01-220 1907	3 Sept. 1924 - 6 Mar. 1925	0.001 ± 0.0005	0.001 ± 0.001	0.002 ± 0.001	$(0.2 \pm 0.4) \times 10^{-3}$	$(0.1 \pm 0.5) \times 10^{-3}$	$(0.2 \pm 0.4) \times 10^{-3}$	indeterminate
01-233 1912	24 Oct. 1927 - 8 Aug. 1930; 6 Feb. 1934 - 30 Apr. 1934	0.0006 ± 0.0006	0.001 ± 0.001	0.002 ± 0.001	$(0.3 \pm 0.5) \times 10^{-3}$	$(0.1 \pm 0.5) \times 10^{-3}$	$(0.3 \pm 0.5) \times 10^{-3}$	indeterminate

* based on γ value, assuming 55% Rn exhalation

Table 5 (continued)

case no., year of birth	exposure period	Ra equivalent by γ (μc)	Ra equivalent by Rn (μc)	Total Ra (= γ + Rn) (μc)	1960 MsTh by γ (μc)	1960 MsTh by Tn (μc)	best measurement of 1960 MsTh (μc)	MsTh/Ra in 1926 or last exposure if earlier (μc/μc)
01-273 1907	13 Mar. 1924 - 19 Mar. 1924	0.0000 ± 0.0006	0.002 ± 0 001	0.002 ± 0.001	$(-0.1 \pm 0.5) \times 10^{-3}$	$(0.7 \pm 0.6) \times 10^{-3}$	$(-0.1 \pm 0.5) \times 10^{-3}$	indeterminate
01-293 1911	6 July 1924 - 3 Oct. 1924	0.0008 ± 0.0005	0.001 ± 0.001	0.002 ± 0.001	$(-0.6 \pm 0.3) \times 10^{-3}$	-	$(-0.6 \pm 0.3) \times 10^{-3}$	indeterminate
01-266 1904	25 June 1923 - 14 July 1923	0.0005 ± 0.0006	0.001 ± 0.001	0.0015 ± 0.001	$(0 \pm 0.4) \times 10^{-3}$	$(-0.7 \pm 0.5) \times 10^{-3}$	$(0 \pm 0.4) \times 10^{-3}$	indeterminate
01-219 1910	21 Sep. 1927 - 30 Nov. 1927	0.0004 ± 0.0005	0.001 ± 0.001	0.001 ± 0.001	$(-0.1 \pm 0.5) \times 10^{-3}$	$(0.2 \pm 0.4) \times 10^{-3}$	$(-0.1 \pm 0.5) \times 10^{-3}$	indeterminate
01-235 1908	22 Sep. 1925 - 18 Nov. 1925	0.0002 ± 0.0004	0.0007 ± 0.001	0.001 ± 0.001	$(-0.3 \pm 0.5) \times 10^{-3}$	$(-0.7 \pm 0.4) \times 10^{-3}$	$(-0.3 \pm 0.5) \times 10^{-3}$	indeterminate
01-238 1896	11 Oct. 1920 - 20 Oct. 1920	0.0006 ± 0.0007	0.0007 ± 0.001	0.001 ± 0.001	$(-0.2 \pm 0.5) \times 10^{-3}$	$(0.6 \pm 0.4) \times 10^{-3}$	$(-0.2 \pm 0.5) \times 10^{-3}$	indeterminate
01-086 1907	28 Oct. 1925 - 23 Nov. 1925	0.000 ± 0.001	0.000 ± 0.001	0.000 ± 0.002	-	$(-0.1 \pm 0.7) \times 10^{-3}$	$(0.1 \pm 0.7) \times 10^{-3}$	indeterminate
01-127 1908	17 Oct. 1927 - 20 Dec. 1927	-0.0016 ± 0.0009	0.002 ± 0.001	0.000 ± 0.002	$(-0.9 \pm 0.5) \times 10^{-3}$	$(-0.4 \pm 0.5) \times 10^{-3}$	$(-0.9 \pm 0.5) \times 10^{-3}$	indeterminate
01-225 1906	14 July 1932 - 15 Aug. 1932, 3 Jan. 1933 - 12 June 1933	-	0.000 ± 0.001	0.000 ± 0.002 *	-	$(-0.7 \pm 0.6) \times 10^{-3}$	$(-0.7 \pm 0.6) \times 10^{-3}$ **	indeterminate
01-226 1915	22 Feb. 1927 - 21 July 1927	0.0004 ± 0.0005	-0.0003 ± 0.001	0.000 ± 0.002	$(0.2 \pm 0.4) \times 10^{-3}$	$(-0.1 \pm 0.6) \times 10^{-3}$	$(0.2 \pm 0.4) \times 10^{-3}$	indeterminate
01-200 1910	18 Nov. 1925 - 11 Apr. 1929; 5 June 1930 - 7 Apr. 1931	0.0003 ± 0.0006	0.000 ± 0.001	0.000 ± 0.001	$(-0.6 \pm 0.6) \times 10^{-3}$	$(0.2 \pm 0.7) \times 10^{-3}$	$(-0.6 \pm 0.6) \times 10^{-3}$	indeterminate
01-203 1908	2 Feb. 1923 - 7 Feb. 1923	-0.0004 ± 0.0006	0.000 ± 0.001	0.000 ± 0.001	$(-0.7 \pm 0.6) \times 10^{-3}$	$(-0.2 \pm 0.5) \times 10^{-3}$	$(-0.7 \pm 0.6) \times 10^{-3}$	indeterminate
01-215 1898	17 Nov. 1925 - 3 Dec. 1925	0.0000 ± 0.0006	-0.0005 ± 0.001	0.000 ± 0.001	$(-0.5 \pm 0.6) \times 10^{-3}$	$(1.4 \pm 0.6) \times 10^{-3}$	$(-0.5 \pm 0.6) \times 10^{-3}$	indeterminate
01-216 1903	14 Feb. 1924 - 10 Mar. 1924	0.0007 ± 0.0006	-0.0008 ± 0.001	0.000 ± 0.001	-	$(0.4 \pm 0.5) \times 10^{-3}$	$(-0.4 \pm 0.5) \times 10^{-3}$	indeterminate
01-230 1913	4 Oct. 1927 - 13 Feb. 1928	0.0004 ± 0.001	0.000 ± 0.001	0.000 ± 0.001	$(1 \pm 0.6) \times 10^{-3}$	$(0.7 \pm 0.5) \times 10^{-3}$	$(1 \pm 0.6) \times 10^{-3}$	indeterminate
01-234 1913	23 Aug. 1927 - 25 Aug. 1927	0.0005 ± 0.0006	-0.0004 ± 0.001	0.000 ± 0.001	$(0.2 \pm 0.4) \times 10^{-3}$	-	$(0.2 \pm 0.4) \times 10^{-3}$	indeterminate

* based on Rn only

** based on Tn only

Table 5 (continued)

case no., year of birth	exposure period	Ra equivalent by γ (μc)	Ra equivalent by Rn (μc)	Total Ra (= γ + Rn) (μc)	1960 MsTh by γ (μc)	1960 MsTh by Tn (μc)	best measurement of 1960 MsTh (μc)	MsTh/Ra in 1926 or last exposure if earlier (μc/μc)
01-280 1905	27 July 1926 - 13 Sep. 1926	0.0003 ± 0.0005	0.000 ± 0.001	0.000 ± 0.001	$(-0.9 \pm 0.5) \times 10^{-3}$	$(-0.9 \pm 0.5) \times 10^{-3}$	$(-0.9 \pm 0.5) \times 10^{-3}$	indeterminate
01-295 1911	29 July 1927 - 7 Nov. 1927	0.0002 ± 0.0004	0.000 ± 0.001	0.000 ± 0.001	$(-0.3 \pm 0.2) \times 10^{-3}$	-	$(-0.3 \pm 0.2) \times 10^{-3}$	indeterminate
01-296 1908	8 Nov. 1927 - 12 Dec. 1927	0.0003 ± 0.0006	0.000 ± 0.001	0.000 ± 0.001	$(0.2 \pm 0.2) \times 10^{-3}$	-	$(0.2 \pm 0.2) \times 10^{-3}$	indeterminate
01-231 1910	31 Jan. 1930 - 14 Sep. 1931	-0.001 ± 0.001	0.000 ± 0.001	-0.001 ± 0.002	$(-0.9 \pm 0.5) \times 10^{-3}$	$(-0.2 \pm 0.5) \times 10^{-3}$	$(-0.9 \pm 0.5) \times 10^{-3}$	indeterminate
01-118 1909	1 Oct. 1923 - 3 Jan. 1924	-0.0011 ± 0.0004	0.000 ± 0.001	-0.001 ± 0.001	$(-0.7 \pm 0.6) \times 10^{-3}$	$(0.3 \pm 0.5) \times 10^{-3}$	$(-0.7 \pm 0.6) \times 10^{-3}$*	indeterminate
01-237 1907	27 Feb. 1927 - 14 Apr. 1927	0.0001 ± 0.0006	-0.0006 ± 0.001	-0.001 ± 0.001	$(0.5 \pm 0.5) \times 10^{-3}$	$(-0.8 \pm 0.4) \times 10^{-3}$	$(0.5 \pm 0.5) \times 10^{-3}$	indeterminate
01-261 1909	26 Feb. 1927 - 7 May 1927	-0.0008 ± 0.0006	0.000 ± 0.001	-0.001 ± 0.001	$(-0.9 \pm 0.6) \times 10^{-3}$	$(-0.7 \pm 0.6) \times 10^{-3}$	$(-0.9 \pm 0.6) \times 10^{-3}$	indeterminate
01-091 1909	3 Jan. 1927 - 6 Feb. 1931; also 1933 - 1939 intermittent	-0.001 ± 0.001	-	-0.002 ± 0.002 **	$(-0.3 \pm 0.6) \times 10^{-3}$	$(0.6 \pm 0.6) \times 10^{-3}$	$(-0.3 \pm 0.6) \times 10^{-3}$	indeterminate

* from γ measurement

** based on γ value

Table 6. All subjects included in this table are persons formerly employed as dial painters at plants other than the Waterbury Clock Company and the New England Watch Company. For information on the column headings and the listed errors see section A9 (pp. 15-16) of this report.

Table 6.

Dial painters

other than Waterbury Clock Co. and New England Watch Co.

case no., year of birth	exposure period	Ra equivalent by γ (μc)	Ra equivalent by Rn (μc)	Total Ra (= γ + Rn) (μc)	1960 MsTh by γ (μc)	1960 MsTh by Tn (μc)	best measurement of 1960 MsTh (μc)	MsTh/Ra in 1926 or last exposure if earlier (μc/μc)
01-183 1900	1915 - 1917	0.104 ± 0.003	0 20 ± 0.01	0.30 ± 0 01	$(-1.2 \pm 0.6) \times 10^{-3}$	$(-0.6 \pm 0.5) \times 10^{-3}$	$(-1.2 \pm 0.6) \times 10^{-3}$	< 0.2
01-268 1901	6 mos. 1916, 6 mos. 1918	0.047 ± 0.006	0.063 ± 0.004	0.110 ± 0.008	$(3.2 \pm 0.6) \times 10^{-3}$	$(3.9 \pm 0.6) \times 10^{-3}$	$(3.2 \pm 0.6) \times 10^{-3}$	2.1 ± 0.4
01-248 1903	1917 - 1921	0.018 ± 0.003	0.023 ± 0.001	0.041 ± 0.003	$(0.5 \pm 0.5) \times 10^{-3}$	$(-0.2 \pm 0.6) \times 10^{-3}$	$(0.5 \pm 0.5) \times 10^{-3}$ *	0.6 ± 0.6
01-204 1901	1917 (3 - 6 mos.)	0.0007 ± 0.0004	0.004 ± 0.001	0.005 ± 0.001	$(-0.6 \pm 0.6) \times 10^{-3}$	$(-0.07 \pm 0.5) \times 10^{-3}$	$(-0.6 \pm 0.6) \times 10^{-3}$	indeterminate
01-228 1906	15 Mar. 1926 - 25 May 1926	-0.0007 ± 0.001	0 004 ± 0.001	0.003 ± 0.002	$(-0.3 \pm 0.6) \times 10^{-3}$	$(0.8 \pm 0.6) \times 10^{-3}$	$(-0.3 \pm 0.6) \times 10^{-3}$	indeterminate
01-283 1895	1917 - 1918	0.001 ± 0.001	0.002 ± 0.001	0.003 ± 0.002	$(0.5 \pm 0.3) \times 10^{-3}$	$(-0.2 \pm 0.5) \times 10^{-3}$	$(0.5 \pm 0.3) \times 10^{-3}$	indeterminate
01-255 1920	1942 - 1943	-0.002 ± 0.001	0.004 ± 0.001	0.002 ± 0.002	$(-0.7 \pm 0.7) \times 10^{-3}$	$(0.6 \pm 0.7) \times 10^{-3}$	$(-0.7 \pm 0.7) \times 10^{-3}$	indeterminate
01-161 1896	Aug. 1918 - Nov. 1918	0.0001 ± 0.0006	0.001 ± 0.001	0.001 ± 0.001	$(-0.4 \pm 0.5) \times 10^{-3}$	$(0.3 \pm 0.5) \times 10^{-3}$	$(-0.4 \pm 0.5) \times 10^{-3}$	indeterminate
01-166 1897	1917 - 1918	0.0005 ± 0.0006	0.000 ± 0 001	0.000 ± 0.001	$(0.2 \pm 0.7) \times 10^{-3}$	$(0 \pm 0.7) \times 10^{-3}$	$(0.2 \pm 0.7) \times 10^{-3}$	indeterminate

* based on γ measurement

Table 7. The subject listed in this table is a living person who drank Radithor during the period 1925-1930. For information on the column headings and the listed errors see section A9 (pp. 15-16) of this report.

Table 7.

Radithor

case no., year of birth	exposure period	Ra equivalent by γ (μc)	Ra equivalent by Rn (μc)	Total Ra (= γ + Rn) (μc)	1960 MsTh by γ (μc)	1960 MsTh by Tn (μc)	best measurement of 1960 MsTh (μc)	MsTh/Ra in 1926 or last exposure if earlier (μc/μc)
01-017 1883	drank ~400 bottles Radithor, 1926 - 1929	0.47 ± 0.04	0.68 ± 0.05	1.15 ± 0.07	0.021 ± 0.001	(26 ± 1) x 10^{-3}	0.021 ± 0.001	0.46 ± 0.02

Table 8. All subjects included in this table are living persons who formerly worked in Ra and/or MsTh refineries or laboratories. For information on the column headings and the listed errors see section A9 (pp. 15-16) of this report.

Table 8.

Chemists

case no., year of birth	exposure period	Ra equivalent by γ (μc)	Ra equivalent by Rn (μc)	Total Ra (= γ + Rn) (μc)	1960 MsTh by γ (μc)	1960 MsTh by Tn (μc)	best measurement of 1960 MsTh (μc)	MsTh/Ra in 1926 or last exposure if earlier (μc/μc)
01-208 1901	1934 - present	0.47 ± 0.01	0.82 ± 0.06	1.29 ± 0.06 *	0.000 ± 0.001	$(3 \pm 1) \times 10^{-3}$	0.000 ± 0.001	< 0.001
01-214 1890	1915 - 1924; 1942 - 1958	0.034 ± 0.003	0.048 ± 0.005	0.082 ± 0.006	$(-3 \pm 2) \times 10^{-3}$	$(0.5 \pm 0.5) \times 10^{-3}$	$(-3 \pm 2) \times 10^{-3}$	< 0.01 **
01-282 1893	1916 - 1921	0.027 ± 0.001	0.028 ± 0.002	0.055 ± 0.002	$(0.1 \pm 0.3) \times 10^{-3}$	$(0.5 \pm 0.6) \times 10^{-3}$	$(0.1 \pm 0.3) \times 10^{-3}$	0.1 ± 0.3
01-205 1921	1951 - 1952	0.0040 ± 0.0007	0.010 ± 0.001	0.014 ± 0.002	$(1.1 \pm 0.6) \times 10^{-3}$	$(-0.5 \pm 0.6) \times 10^{-3}$	$(1.1 \pm 0.6) \times 10^{-3}$	indeterminate
01-210 1878	1917 - 1957	0.0029 ± 0.0006	0.009 ± 0.001	0.012 ± 0.001	$(-0.4 \pm 0.6) \times 10^{-3}$	$(-0.4 \pm 0.6) \times 10^{-3}$	$(-0.4 \pm 0.6) \times 10^{-3}$	indeterminate
01-221 1892	1916 - 1925	0.005 ± 0.001	0.006 ± 0.001	0.011 ± 0.002	$(-0.3 \pm 0.7) \times 10^{-3}$	$(-1.4 \pm 4.7) \times 10^{-3}$	$(-0.3 \pm 0.7) \times 10^{-3}$	indeterminate
01-206 1896	1918 (4 mos.)	0.004 ± 0.001	0.004 ± 0.002	0.008 ± 0.002	$(-0.7 \pm 0.6) \times 10^{-3}$	$(0.7 \pm 0.6) \times 10^{-3}$	$(-0.7 \pm 0.6) \times 10^{-3}$	indeterminate
01-247 1901	1924 - 1927	0.003 ± 0.004	0.002 ± 0.001	0.005 ± 0.004	-	$(-1.0 \pm 0.4) \times 10^{-3}$	$(-1 \pm 0.4) \times 10^{-3}$	indeterminate
01-217 1894	1914 - 1918	-0.001 ± 0.001	0.006 ± 0.001	0.005 ± 0.002	$(-0.4 \pm 0.7) \times 10^{-3}$	$(-0.08 \pm 0.6) \times 10^{-3}$	$(0.4 \pm 0.7) \times 10^{-3}$	indeterminate
01-284 1892	1943 - 1957	0.0004 ± 0.0005	0.005 ± 0.002	0.005 ± 0.002	$(0.1 \pm 0.3) \times 10^{-3}$	$(-0.04 \pm 0.4) \times 10^{-3}$	$(0.1 \pm 0.3) \times 10^{-3}$	indeterminate
01-218 1924	1950 - 1951 (18 mos.)	0.001 ± 0.002	0.001 ± 0.001	0.002 ± 0.002	-	$(15 \pm 9) \times 10^{-3}$	$(1.5 \pm 1.0) \times 10^{-3}$ x	indeterminate
01-250 1894	~1916 - 1926	-0.0015 ± 0.0009	0.002 ± 0.001	0.000 ± 0.002	$(-0.6 \pm 0.7) \times 10^{-3}$	$(-0.3 \pm 0.6) \times 10^{-3}$	$(-0.6 \pm 0.7) \times 10^{-3}$	indeterminate

* also had 2.6 μc Cs^{137}

** as of 1958; presumably fairly low as of 1924

x based on Tn only

Table 9. The individuals listed in this table are living persons whose exposure to radioactive materials was by Thorotrast injection. For information on the colums headings and the listed errors see section A9 (pp. 15-16) of this report.

Table 9.

Thorotrast

case no., year of birth	exposure period	Ra equivalent by γ (μc)	Ra equivalent by Rn (μc)	Total Ra (= γ + Rn) (μc)	1960 MsTh by γ (μc)	best measurement of 1960 MsTh (μc)	MsTh/Ra in 1926 or last exposure if earlier (μc/μc)
01-212 1894	1943	*	0.005 ± 0.001	0.009 ± 0.002	0.48 ± 0.002	0.48 ± 0.002	presumably pure Thorotrast
01-211 1907	1950	*	0.001 ± 0.001	0.002 ± 0.002	0.34 ± 0.01	0.34 ± 0.01	presumably pure Thorotrast
01-202 1925	1948	*	0.0017 ± 0.001	0.003 ± 0.001	0.17 ± 0.02	0.17 ± 0.02	presumably pure Thorotrast
01-213 1894	1934	*	0 000 ± 0.001	0.000 ± 0.002	0.145 ± 0.015	0.145 ± 0.015	presumably pure Thorotrast
01-155 1900	1954	*	0.003 ± 0.001	0.005 ±0.002	0.144 ± 0.005	0.144 ± 0.005	presumably pure Thorotrast
01-286 ~1918	1942, 1943	*	0.001 ± 0.001	0.002 ± 0.002	0.077 ± 0.001	0.077 ± 0.001 **	presumably pure Thorotrast
01-290 x 1906	date of Thorotrast injection unknown	-	0.000 ± 0.001	0.021 ± 0.001	0.025 ± 0.001	0.025 ± 0.001 **	-

Note: col. 7 not applicable, therefore omitted from this table

* obscured by Th γ rays

** μc RdTh

x also was a dial painter at New England Watch Co. during summer months between 1920 and 1924

Table 10. The two subjects included in this table received medical therapy in the form of Ra injections and/or Ra water. For information on the column headings and the listed errors see section A9 (pp. 15-16) of this report.

Table 10.

Medical cases

case no., year of birth	exposure period	Ra equivalent by γ (μc)	Ra equivalent by Rn (μc)	Total Ra (= γ + Rn) (μc)	1960 MsTh by γ (μc)	1960 MsTh by Tn (μc)	best measurement of 1960 MsTh (μc)	MsTh/Ra in 1926 or last exposure if earlier (μc/μc)
01-179 1890	radium injections and Ra water, 1924	0.92 ± 0.008	1.13 ± 0.13	2.05 ± 0.15	$(2 \pm 5) \times 10^{-3}$	$(0.2 \pm 0.7) \times 10^{-3}$	$(0.2 \pm 0.7) \times 10^{-3}$	$(4 \pm 14) \times 10^{-3}$
01-232 1908	"Ra water," 10 mos., ~ 1926	0.0009 ± 0.0005	-0.001 ± 0.001	0.000 ± 0.001	$(-0.4 \pm 0.6) \times 10^{-3}$	$(3 \pm 2) \times 10^{-3}$	$(-0.4 \pm 0.6) \times 10^{-3}$	indeterminate

Table 11. The individuals listed in this table are living persons whose exposure to radioactive materials was by occupation (dial painters, laboratory workers) or by medical therapy. In all cases the body burden of these persons was measured by one breath flask only. For information about the reported values see section A9 (pp. 15-16) of this report.

Table 11.

Persons measured by one breath flask only

case no., year of birth	type of exposure	exposure period	Ra burden (μc)
01-244 1901	dial painter	25 May 1927 - 24 Sep. 1927	<0.107
01-303 1919	dial painter	1940 - 1942	<0.104
01-272 ~1888	lab. worker	1956 - 1959	<0.078
01-276 ~1930	lab. worker	intermittent, 1945 - 1948	<0.060
01-246 1885	lab. worker	~9 mos., 1915 - 1916	<0.045
01-253 1898	dial painter	~1916 - 1918	<0.043
01-278 ~1904	lab. worker	~1925	<0.035
01-249 1928	son of dial painter, case 01-049	-	<0.033
01-267 1904	dial painter	1926 - 1929	<0.030
01-245 1920	dial painter	~3 mos., 1957	<0.025
01-279 1901	lab. worker	1928 - 1948	<0.021
01-260 1891	Ra water	~1918 - 1923	<0.015
01-256 1920	physicist	1949 - 1952	<0.014
01-258 -	chemist	1923 - 1924; intermittent, 1927 - 1944	<0.011
01-262 ~1900	lab. worker	1918 or 1919	<0.011
01-269 ~1911	lab. worker	1932	<0.011
01-259 1910	lab. worker	~1927 - 1937	<0.010

Table 12. The individuals listed in this table are living persons whose exposure to radioactive materials was by occupation (dial painters, laboratory workers) or by medical therapy. In all cases the body burden of these persons was measured by two or more breath flasks only. For information about the indicated errors see section A9 (pp. 15-16) of this report.

Table 12.

Persons measured by two or more breath flasks

case no., year of birth	type of exposure	exposure period	Ra burden (μc)
01-264 1906	lab. worker	1945 - 1960	1.12 *
01-302 ~1900	Ra injections	~1928	0.56
01-305 1925	chemist	1947 -	0.47
01-146 1881	drank Radithor	~750 bottles 1927 - 1929	0.11
01-306 -	chemist	-	0.086
01-193 1886	chemist	4 yrs., 1920 - 1930	0.05
01-251 ~1889	chemist	1912 - 1915	0.05
01-252 ~1899	dial painter	1917 - 1919	0.04
01-274 1906	scraped radium dials	Aug. 3 1922 - Sep. 9 1922	0.03
01-301 1904	"Ra" injections	1926	0.03
01-275 ~1930	chemist	1959	0.02
01-299 1896	dial painter	~1917 - 1918	0.02
01-307 -	chemist	-	0.02
01-263 1897	dial painter	~4 mos., 1917 or 1918	0.01
01-271 1899	dial painter	1 yr. 9 mos., 1917 - 1918	0.01
01-188 1886	drank Ra water	< 1933	0.004
01-257 ~1885	chemist	1941 - 1953	-0.01
01-270 -	dial painter	1943	-0.014

* room air bkgd. very high; results not considered reliable

10. Individual Medical Reports

During the past year, complete physical examinations have been done on patients studied at M.I.T. who had some type of exposure to Ra, Thorotrast, or other radioactive materials in the past. Laboratory procedures similar to those in preceding years have been carried out. A more rigid technique has been followed in both taking and reading of the x-ray films (see section A11). After discussion with the ANL-ACRH group in Chicago a new x-ray scoring system was agreed upon and is presently being used by both laboratories.

One new case of malignancy and one new case having pathological fracture were found during the year. One individual was exposed to two sources of radioactive materials. She was a dial painter in the early 1920's at a plant where both Ra and MsTh were present in the luminous material, and she is also believed to have had a Thorotrast injection.

Another phase of the investigation was started when exhumation of a patient who died 23 years ago was carried out. From this one case it was found that while the coffin had disintegrated almost completely due to the wetness of the grave and the soft parts of the body had disappeared, the bones were in a surprisingly good state of preservation. All but a very few of the small bones were recovered. It would appear that exhumation of similar cases might be a fruitful source for further study.

Table 13. A summary of data on luminous dial painters, with particular reference to Ra content, occupational history, past medical and dental history, marital status, fertility, physical examination, x-ray and laboratory findings. Brief summaries of all cases will be found following Table 14. Complete histories are given in the appendix, together with a list of normal values for the laboratory tests done. Only significant abnormal results of laboratory work are included here. The gradations in amount of brush tipping and in severity of dental pathology are as follows:

brush tipping:

1+ occasional, over an indeterminate time period
2+ frequently, up to 1 month
3+ routine pointing of brush in mouth, for less than 6 months
4+ routine pointing of brush in mouth, for 6 months or more

dental pathology:

1+ slight to moderate dental caries or pyorrhea, or loss of 1 to 6 teeth
2+ severe caries or pyorrhea, or loss of over half the teeth
3+ loss of all teeth but without osteomyelitis or necrosis of jaw
4+ severe dental pathology with loss of many teeth and history of osteomyelitis or necrosis of jaw

Table 13.

Summary of physical findings and body burdens of dial painters

patient; year of birth	exposure; duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of radiation exposure	brush tipping	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-002 1906	1922-1926	18	14	16	severe	4+	4+	S	0	osteomyelitis upper jaw, ununited fractures rt. astragalus	-	severe radiation osteitis; necrosis lumbar vertebra	alk. phos. low; increased wbc	died 1939, ? leukemia; renal failure
01-008 1900	6-8 mos. 1917-1918	5-6	41	17	severe	4+	3+	S	0	fracture rt. femur 1945, deafness beginning 1950	-	marked radiation osteitis	anemia	died 1958 ca of sinus
01-014 1901	1916-1919	3	32	16	severe	4+	4+	M	1	severe osteomyelitis, severe pain lt. neck, left facial neuralgia	-	severe radiation osteitis	anemia	died 1949, ca of nasopharynx
01-292 ~1903	1919-1922	2.9	11	16	severe	4+	-	M	2	-	-	osteogenic sarcoma, rt. ilium, osteogenic sarcoma rt. orbit; radiation osteitis skull	-	died 1930; 2 primary sarcomas, rt. orbit & rt. ilium
01-009 1897	1918-1919	2.8	22	21	severe	4+	-	M	1	osteogenic sarcoma of tibia	-	-		died 1945; osteogenic sarcoma, tibia
01-016 1893	1921-1925	~2.5	39	28	minimal	?	3+	M	1	-	-	-	-	good
01-172 1898	2½ yrs., 1918-1921	1.8	42	19	moderate	4+	3+	M	1	fracture patella 1955, fracture rt. foot 1956; ? glaucoma	negative	radiation osteitis, fracture lt. patella and rt. foot	sl. elevation sed. rate	fair
01-054	3 yrs. 10 mos., 1924-1928	1.65	13	16	severe	4+	-	M	-	fracture rt. femur, 1933	-	extensive radiation osteitis	-	died 1937, Ra poisoning
01-052 1910	1924-1927	1.6	6	14	severe	4+	-	-	-	-	-	-	-	died 1930, Ra poisoning, brain abscess
01-149 1881	6 mos., 1919-1920	1.5	40	31	severe	4+	3+	M	2	fracture rt. femur 1939	paresis, 6th nerve rt. eye, deafness	radiation osteitis, long bones	mod. anemia; elevated wbc	died 1959; ca paranasal sinuses
01-032 1908	1924-1928	1.4	16	16	severe	4+	4+	M	1	tumor lt. hip, anemia	-	-	-	died 1940; osteogenic sarcoma lt. femur, necrosis mandible, multiple metastases

Table 13 (continued)

patient, year of birth	exposure, duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of radiation exposure	brush tipping	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-049 1903	~5 days 1920	1.0	17	16	severe	1+	4+	M	1	-	-	-	-	died 1937, Ra poisoning, osteomyelitis maxillae, otitis media, anemia
01-079 1901	$17\frac{1}{2}$ years 1920-1943	0.75	23	19	severe	4+	-	S	-	tumor, rt femur	-	-	-	died 1943, osteogenic sarcoma, rt. femur
01-046 1903	13 years 1920-1933	0.54	23	17	severe	4+	-	M	-	-	-	radiation osteitis	-	died 1943, osteogenic sarcoma, rt. leg
01-087 1905	$7\frac{1}{2}$ years 1921-1928	0.45	39	14	severe	4+	-	M	1	bilateral cataracts, osteomyelitis mandible, ankylosis hips, many fractures of ribs and both femurs, carcinoma lt. ear 1957	-	severe radiation osteitis	-	poor, carcinoma, lt. ear
01-023 1907	1924-1950	0.4	30	17	severe	4+	-	M	1	-	-	radiation osteitis	-	died 1954, fibrosarcoma ischium
01-132 1908	1 yr. 9 mos. 1923-1925	0.36	~20	15	severe	4+	4+	M	2	otitis media, left, hemorrhage, lt. ear	-	severe destruction skull and long bones	-	died 1944, necrosis and abscess temporal region, meningitis, ankylosis hips
01-183 1900	1915-1917	0.30	44	15	moderate	4+	2+	M(2)	1	lues 1924, severe arthritis 1955 to present, cholecystectomy 1957	rheumatoid arthritis	minimal radiation osteitis, score $5\frac{1}{2}$	elevated sed. rate	fair
01-115 1908	6 yrs. 4 mos. 1924-1930	0.27	20	15	severe	-	2+	M		-	severe pain, lt. thorax and arm	probable osteogenic sarcoma lt. humerus	-	died 1944, Ra poisoning
01-048 1903	~4 yrs. 1920-1927	0.23	40	20	minimal	4+	3+	S	-	occ. pain back and ribs, arthritis hands	-	mild changes as of 1957	-	good
01-126 1903	8 years 1922-1931	0.188	38	18	moderate	4+	3+	M	0	hypertension	hypertension, mild varicose veins	mild radiation osteitis score 15	normal	good
01-268 1901	6 mos. 1916, 6 mos. 1918	0.11	43	15	severe	4+	2+	M	2	osteogenic sarcoma of sternum 1959, resection	recurrence of sarcoma in sternum	advanced, score 12T	-	poor

Table 13 (continued)

patient; year of birth	exposure; duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of radiation exposure	brush tipping	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-244 1901	4 mos., 1927	0 107	32	26	none apparent	-	-	M	5	dementia praecox, catatonic 1939	-	-	-	apparently good
01-303 -	~2 years, 1940-1942	0.104	~20	-	none apparent	-	-	-	-	-	-	-	-	good
01-080 1902	~3 years 1921-1924	0.083	39	18	moderate	4+	3+	M(2)	0	spont. fracture lt. femur 1957	negative	mild radiation osteitis score 17F	normal	good
01-112 1908	11 yrs. 4 mos. 1924-1935	0.08	31	16	severe	4+	-	M	-	pain and swelling rt. arm 1953, amputation arm 1954	-	tumor of rt. upper arm	-	died 1955, gen. carcinomatosis
01-084 1904	9 years 1923-1935	0.068	37	18	minimal	4+	3+	M(2)	0	noncontrib.	negative	minimal radiation osteitis, score 9	normal	good
01-136 1907	$3\frac{1}{2}$ years 1923-1927	0.063	36	15	none	4+	1+	M	1, 2 misc	noncontrib	negative	minimal radiation osteitis	negative	good
01-253 1898	~1916-1918	0.043	43	~18	none apparent	-	-	M	-	hysterectomy 1929, allergy to house dust	-	-	-	good
01-248 1903	1917-1921	0.041	42	14	none	4+	1+	S	0	noncontrib.	negative	negative	normal	good
01-252 ~1899	1917-1919	0.04	42	18	none apparent	-	3+	M	-	-	-	negative	-	fair
01-267 1904	2-3 years ~1924-1927	0.030	35	~20	none apparent	4+	-	M	1	-	-	-	-	good
01-274 1906	scraped dials 1 month, 1922	0.03	37	16	none apparent	-	-	M	-	-	-	-	-	good
01-096 1909	~6 years 1927-1936	0.027	33	17	none	0	1+	M	1, 1 still birth	hysterectomy 1938, cholecystectomy 1954	negative	negative	normal	good
01-201 1911	~14 months 1925-1927	0.026	34	14	none	4+	1+	M	4	noncontrib.	negative	negative	normal	good
01-245 1920	~7 months 1957	0.025	2	37	none apparent	-	-	M	-	-	-	-	-	good
01-299 1896	~1917-1918	0.02	42	~21	none apparent	-	-	M	-	-	-	-	-	good

Table 13 (continued)

patient, year of birth	exposure, duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of radiation exposure	brush tipping	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-297 1901	5 mos., 1921-1923	0.016	39	19	minimal	3+	2+	M(2)	0	two nervous breakdowns between 1950 and 1960, chronic otitis media	moderate bilateral deafness, loud apical systolic murmur	minimal radiation osteitis score 7	normal	good
01-263 1897	4 mos., 1917-1918	0.01	~42	~19	none apparent	-	-	M	-	-	-	-	-	good
01-271 1899	1 yr. 8 mos., 1917-1918	0.01	42	18	none apparent	4+	-	M	-	-	-	-	-	good
01-095 1907	~6 weeks, 1922, 1923	0.0087	37	15	none	2+	3+	M	1	noncontrib.	negative	negative	normal	good
01-038 1910	1927-1929	0.008	32	17	none	0	1+	M	4, 1 misc	noncontrib.	negative	negative	sl. elevation blood sugar and sed. rate	good
01-229 1903	2 weeks, 1923	0 008	36	19	none	2+	3+	M	3	? peptic ulcer, bilateral oophorectomy, 1940	enlarged thyroid	? radiation osteitis	sl. glycosuria & elevated blood sugar	good
01-081 1907	$2\frac{1}{2}$ mos., 1923	0 007	36	15	none	2+	2+	M	3	noncontrib.	negative	negative	normal	good
01-055 1907	~3 mos., 1925-1926	0.006	34	18	none	4+	3+	M	3	hypertension since 1929, 3 Caesarian births	mod. hypertension	negative	normal	good
01-209 1908	3 mos , 1926-1927	0.006	33	17	none	4+	3+	M	0	hypertension, varicose veins	hypertension, obesity	negative	normal	good
01-289 1899	$1\frac{1}{2}$ years, 1919-1921	0.006	41	19	none	4+	2+	M(2)	3, 2 misc	hypertension, many years	mod. hypertension	negative	normal	good
01-204 1901	3-6 mos., 1917	0.005	42	~16	none	0	0	M	2	noncontrib	obesity, hypertension	negative	normal	good
01-287 1908	7 mos., 1927-1928	0.005	33	19	none	0	3+	M	2	diabetes 1957	negative	negative	mod. elev. blood sugar, glycosuria	good
01-291 1910	4 mos., 1928	0.005	32	17	none	0	3+	M	1	diabetes, psoriasis, cholecystectomy 1950, angina pectoris 1959	mild diabetes, angina pectoris	negative	2+ glycosuria	poor
01-039 1913	~3 yrs , 1934-1937	0.004	25	20	none	0	1+	S	0	noncontrib	obesity, varicose veins	bursitis, both shoulders	normal	good
01-041 1909	5 mos , 1927	0.004	32	18	none	0	3+	M	2	gyn. repair 1956, infectious hepatitis 1957	negative	negative	normal	good

Table 13 (continued)

patient; year of birth	exposure; duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of radiation exposure	brush tipping	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-093 1904	2 mos., 1926	0.004	33	21	none	0	3+	M	1	noncontrib.	negative	negative	normal	good
01-207 1909	2 mos., 1927	0.004	32	18	none	0	2+	M	1	severe chronic indigestion	negative	negative	normal	fair
01-285 1900	1 week, 1923	0.004	37	23	none	0	2+	M	3	noncontrib.	negative.	negative	elevated blood sugar	good
01-050 1911	2 mos., 1925	0.003	34	14	none	3+	0	M	2	cholecystectomy 1948	negative	negative	normal	good
01-113 1912	6 weeks, 1928	0.003	31	16	none	0	3+	M	3	deafness, hypertension	deafness, hypertension	negative	sl. elevation blood sugar	good
01-228 1906	2 mos., 1926	0.003	34	19	none	0	3+	M	2	noncontrib.	moderate obesity	negative	normal	good
01-265 1902	2 weeks, 1919	0.003	40	16	none	0	2+	M	0	negative	negative	negative	normal	good
01-283 1895	1917-1918	0.003	43	22	none	-	2+	M	7	varicose veins and dermatitis, lt. ankle, since 1930; cholecystectomy 1931; arthritis since 1957	negative	negative	normal	good
01-294 1912	1927-1928	0.003	33	15	none	0	2+	M	1 ment. ret'd.	cholecystectomy 1930, hysterectomy 1936	essentially negative	negative	normal	good
01-125 1911	6 weeks, 1927	0.002	32	16	none	0	1+	M	4	heart disease since 1941	moderate hypertension and valvular heart disease	negative	normal	fair
01-220 1907	6 mos., 1924-1925	0.002	35	16	none	3+	2+	M	1; 2 misc	hysterectomy 1956; cholecystectomy 1957; hiatus hernia 1958	obesity	negative	normal	good
01-227 1908	assembler, 1950- -	0.002	9	42	none	0	1+	S	0	noncontrib.	negative	negative	sl. elevation of B.U.N. & blood sugar	good
01-233 1912	2 yrs. 9 mos., 1927-1934	0.002	32	15	none	0	2+	M	0	indigestion; substernal pain; hemorrhagic cystitis 1950	negative	negative	normal	good
01-255 1920	1942-1943	0.002	17	22	none	0	1+	M	3	noncontrib.	negative	negative	normal	good
01-273 1907	1 week, 1924	0.002	35	17	none	-	2+	M	0	negative	obesity	negative	normal	good

Table 13 (continued)

patient, year of birth	exposure; duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of radiation exposure	brush tipping	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-288 1896	3 weeks, 1926	0.002	34	29	none	4+	3+	M	4	hypertension	hypertension	minimal changes, rt. humerus	mod. elevation blood sugar	good
01-293 1911	~3 mos., 1924	0.002	36	13	none	0	2+	M	0	hysterectomy 1957	marked obesity, ? glandular dysfunction	negative	sl. elevation blood sugar	good
01-161 1896	4 mos., 1918	0.001	41	21	none	3+	2+	M	2 died at birth	noncontrib.	mild hypertension	negative	normal	good
01-219 1910	2 mos., 1927	0.001	32	17	none	2+	2+	M	1	operation for ? uterine suspension 1958	negative	negative	not done	good
01-235 1908	2 mos., 1925	0.001	34	17	none	3+	2+	S	0	some loss of hearing since 1955	nodule in neck above thyroid isthmus	negative	normal	good
01-238 1896	2 weeks, 1920	0.001	39	23	none	0	3+	M	1	cerebellar degenerative disease 1958	ataxic	negative	normal	fair
01-266 1904	3 weeks, 1923	0.001	37	19	none	0	3+	M	7; 1 still birth; 2 ment. ret'd.	mastoidectomy 1922; loss of vision lt. eye 1931; hysterectomy 1939; bowel resection 1956	obesity, loss of vision lt. eye	negative	mild leucopenia	fair
01-086 1907	1 month, 1925	0.000	36	15	none	0	3+	M	4	noncontrib.	hypertension, dental caries	old fracture, tibia and fibula	not done	good
01-127 1908	2 mos., 1927	0.000	32	19	none	1+	3+	M	3	fracture, 2 lumbar vertebrae 1928	negative	negative	normal	good
01-166 1897	1917-1918	0.000	43	19	none	3+	4+	M	4	? necrosis of maxilla 1922	mod. hypertension, arthrodesis lt. ankle	negative	eosinophilia	fair
01-200 1910	~4 years, 1925-1931	0.000	34	15	none	0	3+	M	2	noncontrib.	negative	negative	normal	good
01-203 1908	1 week, 1923	0.000	36	14	none	1+	3+	S	0	asthma since 1944, mastectomy 1953	obesity, asthma	negative	normal	fair
01-215 1898	$2\frac{1}{2}$ weeks, 1925	0.000	34	27	none	0	3+	M	3	chronic bronchitis, fracture lt. ankle 1959	negative	negative	normal	good
01-216 1903	1 month, 1924	0.000	35	20	none	2+	3+	M	0	hysterectomy 1942, subtotal gastrectomy for ulcer 1946	noncontrib.	sl. osteoporosis radius, ulna, and humerus	normal	fair
01-225 1906	2 mos., 1931	0.000	29	25	none	0	3+	M	1 misc.	thyroidectomy ~1941; hysterectomy 1954; laminectomy 1956	limited straight leg raising	negative	normal	fair

Table 13 (continued)

patient; year of birth	exposure; duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of radiation exposure	brush tipping	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-226 1915	5 mos., 1927	0.000	32	11	none	0	2+	S	0	noncontrib.	*obesity*, minimal hypertension	negative	normal	good
01-230 1913	4 mos., 1927-1928	0.000	32	14	none	0	0	M	1	hysterectomy 1927; ? tbc 1933	? thyroid nodule	negative	not done	fair
01-234 1913	< 1 week, 1927	0.000	32	14	none	0	1+	M	2	hysterectomy 1956	negative	negative	normal	good
01-280 1905	2 mos., 1926	0.000	34	20	none	0	3+	M	3	thyroidectomy 1940, hysterectomy 1951, cholecystectomy 1954	nodule, rt. anterior neck, small mass to rt. of periurethral orifice	negative	4+ glycosuria, elevated blood sugar	good
01-295 1911	$2\frac{1}{2}$ *mos.*, 1927	0.000	33	15	none	0	2+	M	4	hysterectomy 1953	varicose veins, ? hypothyroidism	negative	normal	good
01-296 1908	1 month, 1927	0.000	33	19	none	0	2+	M	2	noncontrib.	negative	negative	normal	good
01-118 1909	3 mos., 1923-1924	-0.001	36	14	none	2+	1+	M	1, 2 misc	fibrositis 1939	negative	negative	mod. elevated wbc	good
01-231 1910	inspector, 1 yr. 8 mos. 1930-1931	-0.001	29	19	none	0	2+	M	0	noncontrib.	negative	negative	normal except for hematocrit 33%	good
01-237 1907	2 mos., 1927	-0.001	32	19	none	0	2+	M	5	noncontrib.	negative	negative	normal	good
01-261 1909	~ 2 weeks, 1927	-0.001	32	17	none	0	2+	M	2	herniated disc of spine 1951, duodenal ulcer 1959	obesity	negative	normal	fair
01-091 1909	~ 5 yrs., 1927-1932	-0.002	32	17	none	0	2+	M	0	noncontrib.	negative	negative	normal	good
01-270 -	7-8 mos., 1943	-0.014	16	-	none apparent	-	-	M	-	-	-	-	-	good

Table 14. A summary of data on individuals exposed to radioactive materials by means other than dial painting, with particular reference to Ra content, occupational history, past medical and dental history, marital status, fertility, physical examination, x-ray and laboratory findings. Brief summaries of all cases will be found following this table. Complete histories are given in the appendix, together with a list of normal values for the laboratory tests done. Only significant abnormal results of laboratory work are included here. The gradations in severity of dental pathology are given below.

1+ slight to moderate dental caries or pyorrhea, or loss of 1 to 6 teeth

2+ severe caries or pyorrhea, or loss of over half the teeth

3+ loss of all teeth but without osteomyelitis or necrosis of jaw

4+ severe dental pathology with loss of many teeth and history of osteomyelitis or necrosis of jaw

Table 14

Summary of physical findings and body burdens of individuals exposed to radioactive materials by means other than dial painting

patient; year of birth	exposure, type, duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of exposure	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-007 1886	Ra injections 1926	9.6	23	40	severe	-	M	-	osteogenic sarcoma, lt. humerus, amputation 1948	-	severe radiation change	anemia	died 1949, osteogenic sarcoma, lt. humerus
01-179 1890	Ra injections and Ra water, 1924-1925	2.05	35	34	severe	2+	M	2	cholecystectomy and oophorectomy 1936, amputation lt. leg for osteogenic sarc 1943	not done	marked radiation osteitis and aseptic necrosis, rt. hum.	not done	fair
01-017 1883	drank ~ 400 bottles Radithor 1926-1929	1.5	33	43	minimal	2+	S	-	noncontrib.	-	2nd path. fracture lt femur 1958	-	good
01-208 1901	chemist 1934-present	1.29 *	25	33	radiation burns of fingers	3+	M	2	varicose veins	negative	negative	normal	good
01-264 1906	repaired luminous dials - 15 yrs. 1944-present	1.12	-	38	none apparent	-	-	-	-	-	-	-	good
01-302 ~1900	Ra injections ~1928	0.56	32	~25	severe	-	-	-	fracture of femur, followed by amputation	-	-	-	fair
01-027 1889	chemist 1912-1932	0.50	45	23	minimal	-	M	2	noncontrib.	-	-	-	died 1957, ca lung
01-305 ~1925	chemist 1947-	0.47	-	~22	none apparent	-	-	-	-	-	-	-	good
01-146 1881	drank ~750 bottles Radithor, 1927-1929	0.11	32	45	none apparent	-	M	-	-	-	-	-	good
01-306 -	chemist	0.086	-	-	none apparent	-	-	-	-	-	-	-	good
01-214 1890	chemist, 1915-1924, 1942-1958	0.082	44	26	none	3+	M(2)	1	negative	mild hypertension, aortic stenosis, prostatic hypertrophy	cardiac hypertrophy	normal	good
01-272 ~1888	lab. worker 1956-1959	0.078	3	68	none apparent	-	-	-	-	-	-	-	good
01-276 ~1930	lab. worker intermit. 1945-1948	0.06	15	15	none apparent	-	-	-	severe arthritis	-	-	-	fair
01-282 1893	chemist 1916-1919	0.055	43	23	none	1+	M	2	noncontrib.	slight hypertension, benign prostatic hypertrophy	negative	normal	good
01-193 1886	chemist, 4 yrs. 1917-1921	0.05	42	31	none apparent	1+	S	0	traumatic fracture of hip, 1951	-	negative in 1951	-	died 1960, coronary disease
01-251 ~1889	chemist 1912-1915	0.05	47	22	none apparent	-	M	-	heart disease	-	-	-	good

* also had 2.6 μc Cs^{137}

Table 14 (continued)

patient; year of birth	exposure; type, duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of exposure	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-246 1885	lab. worker 8-9 mos., 1915-1916	0.045	44	30	none apparent	-	M	-	-	-	-	-	good
01-278 ~1904	lab. worker ~1925	0.035	~34	~30	none apparent	-	M	-	-	-	-	-	good
01-249 1928	son of dial painter case 01-049	0.033	-	-	none apparent	-	M	-	-	-	-	-	good
01-301 1904	"Ra" injections 1926	0.03	33	22	none apparent	-	M	-	low blood count	-	-	-	good
01-275 ~1930	chemist 1959	0.02	-	~29	none apparent	-	-	-	-	-	-	-	good
01-279 1901	lab. worker 1928-1948	0.02	32	27	none apparent	-	-	-	-	-	-	-	good
01-290 * 1906	Thorotrast injection	0.02 (0.025 MsTh)	40	14	none	2+	M	2	multiple illnesses and operations		negative	normal	poor
01-307 -	chemist	0.02	-	-	none apparent	-	-	-	-	-	-	-	good
01-260 1891	drank "Ra water" ~1918-1923	0.015	41	27	none apparent	-	M	1	-	-	-	-	good
01-205 1921	chemist 1951-1952	0.014	8	30	none	0	M	3	noncontrib.	obesity hypertension	negative	normal	fair
01-256 1920	physicist 1949-1952	0.014	10	29	none apparent	-	-	-	-	-	-	-	good
01-210 1878	physicist 1917-1957	0.012	41	40	slight	3+	M	1	"aplastic anemia" age 44	negative	negative	1+ albumin; elevated sed. rate; elevated blood sugar	good
01-221 1892	plant manager 1916-1925	0.011	43	24	none	2+	M(2)	1	removal bladder ca, 1951, removal rt. kidney, ureter, and bladder, 1958	cataract, rt. eye hypertension	negative	normal	good
01-258 ~1900	chemist, intermit. 16 yrs. 1923-1944	0.011	36	~23	none apparent	-	-	-	-	-	-	-	good
01-262 ~1900	lab. worker 1918 or 1919	0.011	~41	~18	none apparent	-	-	-	-	-	-	-	good

* also was dial painter between 1920 and 1924

Table 14 (continued)

patient, year of birth	exposure, type, duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of exposure	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-269 ~1911	lab. worker 1932	0.011	27	~21	none apparent	-	-	-	-	-	-	-	good
01-259 1910	lab. worker ~1927-1937	0.010	32	~17	none apparent	-	M	2	-	-	-	-	good
01-212 1894	Thorotrast 1943	0.009 (0.48 MsTh)	49	16	none	2+	M	2	multiple operations starting with ischiorectal abscess 1943	negative	neg. for radiation osteitis, Thorotrast deposition in reticuloendothelial system and rt. lower leg	normal	fair
01-206 1896	chemist 4 mos., 1918	0.008	41	22	none	2+	M(2)	1, 2 still births	noncontrib.	negative	negative	normal	good
01-155 1900	Thorotrast 1954	0.005 (0.144 MsTh)	5	54	none	3+	M	5	hemiparesis 1954	left hemiparesis due to old cerebral hemorrhage, moderate hypertension	neg. for radiation osteitis, deposition of Thorotrast in liver	normal	poor
01-217 1894	dial painting supervisor 1914-1918	0.005	45	20	none	2+	M	3	noncontrib.	negative	negative	normal	good
01-247 1901	chemist 1923-1926	0.005	36	22	none	2+	M	0	perinephric abscess 1924, radiation burns of fingers 1937	scars from radiokeratotic areas	negative	normal	good
01-284 1892	chemist 1943-1947	0.005	16	51	none	1+	M	1	coronary thrombosis 1955	moderate hypertension and minimal prostatic hypertrophy	negative	slightly elevated wbc and sed. rate	good
01-188 1886	drank "Ra water" < 1933	0.004	~26	~47	none apparent	-	M	-	arthritis, anemia	-	-	-	good
01-202 1925	Thorotrast 1948	0.003 (0 17 MsTh)	11	23	none	1+	M	0	head injury 1943, loss of vision, left eye	loss of vision, left eye	neg. for radiation osteitis, deposition of Thorotrast in spleen	normal	fair
01-211 1907	Thorotrast 1950	0.002 (0.34 MsTh)	9	43	slight	2+	M	0	esophageal varices, splenectomy, spleno-renal shunt	mild hypertension	neg. for radiation osteitis, deposition of Thorotrast in retroperitoneal lymph nodes	elevated sed. rate	poor
01-218 1924	chemist 1950-1951	0.002	9	26	none	1+	M	2	infected parotid gland, removed 1958	negative	negative	normal	good
01-286 ~1918	Thorotrast 1942, 1943	0.002 (0.077 RdTh)	18	~24	none apparent	-	S	-	-	-	-	-	good

Table 14 (continued)

patient, year of birth	exposure, type, duration, date	est. Ra content (μc)	years after initial exposure	age at beginning of exposure	effects of exposure	dental pathology	marital status	number of children	past medical history	physical examination	x-ray findings	laboratory findings	present health
01-213 1894	Thorotrast 1934	0 000 (0.145 MsTh)	25	40	none	3+	M	0	aneurysm of neck vessels, 1934	weight loss, poor vision rt eye, old scoliosis and kyphosis	negative	normal	poor
01-232 1908	drank "Ra water" 10 mos. ~1926	0.000	33	18	none	2+	M	0	nephritis, rheumatic heart disease, tuberculoma rt lung, intervertebral disc, hypothyroidism	moderate hypertension	negative	slight elevation B.U.N.	fair
01-250 1894	chemist 1916-1938	0 000	43	22	none	1+	M	1	noncontrib.	negative	negative	normal	good
01-257 ~1885	chemist 1941-1953	-0.01	18	56	none apparent	-	M	-	severe heart attack, amputation lt. leg 1959	-	-	-	poor

Case history summaries

(01-002) See case 2 (Miss E. C.), Medicine 31, 221 (1952).

(01-007) See case 7 (Mrs. F. W.), Medicine 31, 221 (1952).

(01-008) Born 1900. Died 1958. Luminous dial painter for 6-8 months 1917-1918, starting at age 17. Body burden Ra 4-6 μc. Severe effects from radiation. Edentulous by 1943. Fracture of rt. femur 1945. By 1950 had become hard of hearing. Developed carcinoma of sinuses. Tipped brush regularly. Autopsy revealed carcinoma originating in epithelium of accessory respiratory sinus. X-rays showed extensive radiation osteitis. Lab. findings within normal limits except for anemia.

(01-009) See case 9 (Mrs. F. R.), Medicine 31, 221 (1952).

(01-014) See case 14 (Mrs. H. G.), Medicine 31, 221 (1952).

(01-016) See case 16 (Mrs. K. W.), Medicine 31, 221 (1952) and case (K. Wd.) M.I.T. progress report May 1958. As of 1960 patient is in good health.

(01-017) See case 17 (Miss J. J.), Medicine 31, 221 (1952) and case (J. Ja.) M.I.T. progress report May 1958. In 1958 patient had a second fracture of left femur. By 1960 she had made a reasonably good recovery.

(01-023) See case 23 (Mrs. R. W.), Medicine 31, 221 (1952) and case (R. W.) M.I.T. progress report May 1958.

(01-027) See case 27 (Mr. J. U.), Medicine 31, 221 (1952) and case (01-027) of M.I.T. progress report May 1959.

(01-032) Born 1908. Died 1940. Luminous dial painter for 4 years, 1924-1928, starting at age 16. Developed tumor left hip, anemia. Autopsy showed osteogenic sarcoma of left femur, necrosis of mandible, multiple metastases.

(01-038) Born 1910. Living and in good health. Luminous dial painter for 2 years between 1927 and 1929 at age 17. Body burden Ra 0.008 μc in 1959. No effect demonstrable from radiation 32 years after exposure.
Teeth in good condition, has lost only 5 to date. Married 30 years to present. Four children living and well, one miscarriage. Past medical history not remarkable. Denies tipping brush. Does not remember luminescence of hair and clothing. Present exam negative. X-ray and lab. findings essentially normal.

(01-039) Born 1913. Living and in good health. Assembled "dry radium" watch faces and hands for ~3 years between 1934 and 1937 starting at age 20. Body burden 0.004 μc in 1959. No effect demonstrable from radiation.
Teeth in good condition, has lost only 6 to date. Past medical history non-contributory. Did not tip brush. No luminescence of hair and clothing. Present exam shows obesity and varicose veins. X-rays showed bursitis both shoulders. Lab. findings normal.

(01-041) Born 1909. Living and in good health. Luminous dial painter for 5 months in 1927 starting at age 18. Body burden Ra 0.004 μc in 1959. No effect demonstrable from radiation 32 years after exposure.
Edentulous by 1956. Married 29 years to present. Two children living and well. Gyn. repair in 1956, infectious hepatitis in 1957. Otherwise past medical history noncontributory. Did not tip brush. No luminescence of hair or clothing. Present exam entirely negative. X-ray and lab. findings normal.

(01-046) See case (F. Co.) M.I.T. progress report May 1958.

(01-048) See case (M. Da.) M.I.T. progress report May 1958. As of 1960 patient is living and well.

(01-049) See case (E. Da.) M.I.T. progress report May 1958.

(01-050) Born 1911. Living and in good health. Luminous dial painter for 2 months in 1925 at age 14. Body burden Ra 0.003 μc in 1959. No effect demonstrable from radiation 34 years after exposure.
Teeth in good condition. Married 32 years to present. Two children living and well. Cholecystectomy in 1948. Tipped brush regularly. Present exam, x-ray, and lab. findings negative.

(01-052) Born 1910. Died 1930. Luminous dial painter for about 3 years starting in 1924 at age 14. Death certificate gives cause of death as radium poisoning and brain abscess. No autopsy. Body burden Ra 1.6 μc.

(01-054) Born about 1908. Died 1937. Luminous dial painter for almost 4 years starting in 1924 at age 16. X-rays showed extensive radiation osteitis and fracture of right femur. No autopsy. Body burden Ra 1.65 μc.

(01-055) Born 1907. Living and in good health. Luminous dial painter for about 3 months between 1925 and 1926 starting at age 18. Body burden Ra 0.006 μc in 1959. No effect demonstrable from radiation 34 years after exposure.
Teeth in poor condition, has only 8-10 left. Married 31 years to present. Three children, two living and well, one died of pneumonia at about age 6; all by caesarian section. Has had hypertension for 30 years. Tipped brush regularly. Remembers luminescence of hair and clothing. Present exam shows only moderate hypertension. X-ray and lab. findings normal.

(01-079) Born 1901. Died 1943. Luminous dial painter for 3 years 4 months between 1920 and 1924, 14 years from 1929 to 1943. Spontaneous fracture of right femur and osteogenic sarcoma of right in 1942. No autopsy. Body burden Ra 0.75 μc.

(01-080) Born 1902. Living and in good health. Luminous dial painter for almost 3 years between 1921 and 1924 starting at age 18. Body burden Ra 0.083 μc in 1960. Some effects demonstrable from radiation 39 years after exposure. Edentulous by 1950. Married first time 14 years, second time 12 years to present time, no children with either marriage. Spontaneous fracture left femur in 1957. Tipped brush regularly. No luminescence of hair and clothing. Present exam essentially negative. X-rays showed mild radiation osteitis, score 17F. Lab. findings normal.

(01-081) Born 1907. Living and in good health. Luminous dial painter for 2-1/2 months in 1923, at age 15. Body burden Ra 0.007 μc in 1959. No effect demonstrable from radiation 36 years after exposure.
Teeth in poor condition, has lost 16 to date. Married 33 years to present, 3 children by caesarian section living and well. Past medical history negative. Tipped brush regularly. No luminescence of hair and clothing. Present exam essentially negative. X-rays and lab. findings normal.

(01-084) Born 1904. Living and in good health. Luminous dial painter for 9 years between 1923 and 1935, starting at age 18. Body burden Ra 0.068 μc in 1960. Minimal effects from radiation about 37 years after exposure.
Edentulous by age 36. Married first time 15 years, second time 5 years to present, no children. Past medical history noncontributory. Tipped brush regularly. Present exam not remarkable. X-rays showed minimal radiation osteitis, total score 9. Lab. findings normal.

(01-086) Born 1907. Living and in good health. Luminous dial painter for 1 month in 1925 starting at age 15. Body burden Ra 0.000 ± 0.002 μc in 1959. No effect demonstrable from radiation 36 years after exposure.
Teeth in poor condition, has lost many to date. Married 30 years to present, 4 children living and well. Past medical history noncontributory. Denies tipping brush. No luminescence of hair and clothing. Present exam showed hypertension and dental caries. X-rays essentially negative except for old fracture of tibia and fibula. Lab. work not done.

(01-087) Born 1905. Living and in poor health. Luminous dial painter for 7-1/2 years between 1921 and 1928, starting at age 14. Body burden Ra 0.45 μc. Severe effects demonstrable from radiation 39 years after exposure.
Osteomyelitis of mandible. One child living and well. Tipped brush regularly. Bilateral cataracts, ankylosis of hips, numerous fractures of ribs and both femurs, squamous cell carcinoma of left ear canal. X-rays in 1953 showed severe radiation osteitis. No physical exam, recent x-rays, or lab. work done.

(01-091) Born 1909. Living and in good health. Luminous dial inspector for about 5 years starting in 1927 at age 17. Body burden Ra -0.002 μc in 1959. No effect demonstrable from radiation 32 years after exposure.
Teeth in fair condition. Has lost about 8 to date. Married, no children or miscarriages. Past medical history noncontributory. No brush tipping. No luminescence of hair and clothing. Present exam negative. X-ray and lab. findings negative.

(01-093) Born 1904. Living and in good health. Luminous dial painter for about 2 months in 1926 at age 21. Body burden Ra 0.004 μc in 1959. No effect demonstrable from radiation 33 years after exposure.
Edentulous by 1958. Married 31 years to present, 1 child living and well. No brush tipping. No luminescence of hair and clothing. Past medical history noncontributory. Present exam negative. X-ray and lab. findings negative.

(01-095) Born 1907. Living and in good health. Luminous dial painter for about 6 weeks in 1922 and 1923 starting at age 15. Body burden Ra 0.0087 μc in 1959. No effect demonstrable from radiation 37 years after exposure.
Edentulous by 1945. Married 25 years to present, one child living and well. Tipped brush regularly. Some luminescence of hair and clothing. Past medical history noncontributory. Present exam negative. X-ray and lab. findings normal.

(01-096) Born 1909. Living and in good health. Luminous dial painter for about 6 years between 1927 and 1936 starting at age 17. Body burden Ra 0.027 μc in 1960. No effect demonstrable from radiation 33 years after exposure.
Teeth in fair condition, has lost 10 to date. Married 24 years to present; one child, one stillbirth. Hysterectomy at age 29, cholecystectomy at age 45. No brush tipping. Some luminescence of hair and clothing. Present exam negative. X-ray and lab. findings normal.

(01-112) Born 1908. Died 1955. Luminous dial painter for almost 11 years between 1924 and 1935 starting at age 16. Body burden Ra about 0.08 μc. In 1953 had intrascapular thoracic amputation on right for osteogenic sarcoma. Died of generalized carcinomatosis. No autopsy.

(01-113) Born 1912. Living and in good health. Luminous dial painter for 6 weeks in 1928 starting at age 16. Body burden Ra 0.003 μc in 1959. No effect demonstrable from radiation 31 years after exposure.
Edentulous by 1959. Married 26 years to present. Three children living and well. Moderately severe deafness in both ears, moderate hypertension since 1957. No brush tipping. No luminescence of hair and clothing. Present exam shows only bilateral deafness and moderate hypertension. X-ray and lab. findings normal except for slight elevation of blood sugar.

(01-115) Born 1908. Died 1944. Luminous dial painter for 6 years 4 months starting in 1924 at age 15. Body burden Ra 0.27 μc. Severe effects from radiation.
By 1944 had lost all but 4 teeth. X-rays showed pathologic changes in head of left humerus. Death certificate gives cause of death as radium poisoning. No autopsy.

(01-118) Born 1909. Living and in good health. Luminous dial painter for 3 months in 1923-4 starting at age 14. Body burden Ra -0.001 μc in 1959. No effects demonstrable from radiation 36 years after exposure.
Teeth in good condition, has lost only 6 or 7 to date. Married 31 years to present. One child living and well, two miscarriages. Fibrositis about 1939. Tipped brush regularly. No luminescence of hair and clothing. Present exam negative. X-ray and lab. findings negative except for moderate elevation of white count.

(01-125) Born 1911. Living and in fair health. Luminous dial painter for 6 weeks in 1927. Body burden Ra 0.002 μc in 1959. No effects demonstrable from radiation 32 years after exposure.
Teeth in good condition. Has lost only 6 to date. Married over 26 years to present. Four children living and well. Heart disease since age 30. No brush tipping. Some luminescence of hair and clothing. Present exam shows moderate hypertension and valvular heart disease. X-ray and lab. findings negative.

(01-126) Born 1903. Living and in good health. Luminous dial painter for 8 years between 1922 and 1931 starting at age 18. Body burden Ra 0.188 μc in 1960. Moderate effects demonstrable from radiation 38 years after exposure.
Edentulous by age 38. Married 29 years to present. First marriage 1 year, about 1922, second marriage about 1931 to date. No pregnancies due to sterility on part of husband (second marriage). Hypertension for many years. Tipped brush regularly. Definite luminescence of hair and clothing. Present exam shows only mild varicose veins and hypertension. X-ray shows mild radiation osteitis, score 15. Lab. findings normal.

(01-127) Born 1908. Living and in good health. Luminous dial painter for 2 months in 1927 at age 19. Body burden Ra 0.000 $\pm$ 0.002 μc in 1959. No effect demonstrable from radiation 32 years after exposure.
Edentulous by 1958. Married 28 years to present. Three children living and well, one child died in infancy. Fracture of two lumbar vertebrae at age 20. Tipped brush occasionally. Some luminescence of hair and clothing. Present exam negative. X-ray and lab. findings normal.

(01-132) Born 1908. Died 1944. Luminous dial painter 1 year 9 months starting in 1923 at age 15. Body burden Ra 0.36 μc. Severe effects demonstrable from radiation.
Edentulous by 1944. Married about 11 years. Two children. In 1936 developed ankylosis of hips, otitis media left. X-ray showed extensive destruction due to radium poisoning. Autopsy revealed necrosis of left temporal bone with infection, left temporal lobe abscess, suppurative meningitis, ankylosis of hips.

(01-136) See case 01-136, M.I.T. progress report May 1959.

(01-146) See case 01-146, M.I.T. progress report May 1959.

(01-149) See case 01-149, M.I.T. progress report May 1959.

(01-155) Born 1900. Living and in poor health. Received Thorotrast injection in 1954 at age 54. Body burden MsTh 0.144 μc in 1959. No effect demonstrable from radiation 5 years after exposure.
Edentulous by 1949. Married over 20 years. Five children living and well. Hemiparesis at age 54. Present exam shows left hemiparesis due to old cerebral hemorrhage, moderate hypertension. X-rays show no radiation osteitis but liver shows deposition of Thorotrast. Lab. findings not remarkable.

(01-161) Born 1896. Living and in good health. Luminous dial painter for about 4 months in 1918 at age 21. Body burden Ra 0.001 μc in 1959. No effects from radiation 41 years after exposure.
Teeth in poor condition, has lost 16 to date. Married 40 years to present, two children both of whom died at birth. Past medical history noncontributory. Tipped brush regularly. No luminescence of hair and clothing. Present exam shows mild hypertension. X-ray and lab. findings normal.

(01-166) Born 1897. Living and in fair health. Luminous dial painter for about 1 year, 1917-8, at age 19. Body burden Ra 0.000 ± 0.001 μc in 1959. No effects demonstrable from radiation 43 years after exposure.
Edentulous at age 24. Married 41 years to present. Four children living and well, 11 grandchildren. Past medical history shows ? necrosis of maxilla 4 years after dial painting. Tipped brush regularly. No luminescence of hair and clothing. Present exam shows moderate hypertension, arthrodesis left ankle. X-ray and lab. findings normal except for slight increase in eosinophils.

(01-172) See case 01-172, M.I.T. progress report May 1959.

(01-179) See case 01-179, M.I.T. progress report May 1959. Complete workup of radioactivity measurements done at M.I.T. indicates body burden Ra 2.05 μc in 1959.

(01-183) Born 1900. Living and in fair health. Luminous dial painter for 1-1/2 years starting in 1915 at age of about 15. Body burden Ra 0.30 μc in 1959. Moderate effects demonstrable from radiation 44 years after exposure.
Teeth in fair condition, has lost 16 to date. First marriage 1920-1924, one child living and well. Second marriage 1940 to present, no pregnancies. Past medical history reveals lues in 1924, severe rheumatoid arthritis from age 55 to present, cholecystectomy at age 57. Tipped brush regularly. Marked luminesnence of hair and clothing. Present exam shows rheumatoid arthritis of hands and feet. X-rays shows minimal radiation changes, score 5-1/2. Lab. findings normal except for elevated sedimentation rate.

(01-188) See case 01-188, M.I.T. progress report May 1959. Additional breath samples indicate body burden Ra 0.004 μc in 1959.

(01-193) See case 01-193, M.I.T. progress report May 1959. Patient died in 1960 of coronary disease.

(01-200) Born 1910. Living and in good health. Luminous dial painter and inspector about 4 years between 1925 and 1931 starting at age 15. Body burden Ra 0.000 ± 0.001 μc in 1959. No effects demonstrable from radiation 34 years after exposure.
Teeth in fair condition, has lost 27 to date. Married 15 years to 1950, two children living and well. Past medical history noncontributory. No brush tipping. No luminescence of hair and clothing. Present physical exam negative. X-ray and lab. findings normal.

(01-201) Born 1911. Living and in good health. Luminous dial painter for about 14 months between 1925 and 1927 starting at age 14. Body burden Ra 0.026 μc in 1959. No effect demonstrable from radiation 34 years after exposure.
Teeth in good condition. Has lost only 10 to date. Married 31 years to present. Four children living and well. Past medical history noncontributory. Tipped brush regularly. No luminescence of hair and clothing. Present physical exam negative. X-ray and lab. findings negative.

(01-202) Born 1925. Living and in fair health. Received Thorotrast injection in 1948 at age of about 23. Body burden MsTh 0.17 μc in 1959. No effects demonstrable from radiation 11 years after exposure.
Teeth in good condition. Has lost only 2 to date. Married 6 years, no children. Head injury at age 18 followed by loss of vision in left eye and fainting spells. Angiogram done. Present exam shows loss of vision in left eye. X-rays negative for radiation osteitis; Thorotrast deposition in spleen. Lab. findings normal.

(01-203) Born 1908. Living and in fair health. Luminous dial painter for 1 week in 1923 at age 14. Body burden Ra 0.000 ± 0.001 μc in 1959. No effects demonstrable from radiation 36 years after exposure.
Edentulous by 45. Bronchial asthma for past 15 years; right mastectomy for ? malignancy at age 45. Tipped brush. No luminescence of hair and clothing. Present exam negative except for obesity and asthma. X-ray and lab. findings negative.

(01-204) Born 1901. Living and in good health. Luminous dial painter for 3-6 months in 1917 or 1918 at age 16 or 17. Body burden Ra 0.005 μc in 1959. No effects demonstrable from radiation about 42 years after exposure.
Teeth in good condition. Has lost none to date. Married, 2 children. Past medical history noncontributory. No brush tipping. No luminescence of hair and clothing. Present exam reveals only obesity and hypertension. X-ray and lab. findings negative.

(01-205) Born 1921. Living and in fair health. Chemist in radium plant for 1 year, 1951-2, at age 30. Body burden Ra 0.014 μc in 1959. No effects demonstrable from radiation about 8 years after exposure.
Teeth in good condition. Has lost none to date. Married and has three children living and well. Past medical history shows multiple complaints but all noncontributory. Present physical exam shows only obesity and hypertension. X-rays and lab. findings normal, except for benign cyst left middle toe.

(01-206) Born 1896. Living and in good health. Chemist in radium refinery for 4 months in 1918 at age 22. Body burden Ra 0.008 μc in 1959. No effects demonstrable from radiation 41 years after exposure.
Teeth in fair condition. Has lost 16 to date. Married 1920-1952, one child living and well. Two other children died at birth. Second marriage 1954 to present. Past medical history noncontributory. Present physical exam negative. X-ray and lab. findings negative.

(01-207) Born 1909. Living and in fair health. Luminous dial painter for 2 months in 1927 at age 18. Body burden 0.004 μc in 1959. No effects demonstrable from radiation 32 years after exposure.
Teeth in fair condition. Has lost 24 to date. Married 22 years to present. One child living and well. Has had severe chronic indigestion for many years; past medical history otherwise noncontributory. No brush tipping. No luminescence of hair and clothing. Present physical exam negative. X-ray and lab. findings normal.

(01-208) Born 1901. Living and in good health. Chemist in radium refinery for about 18 years between 1934 and present starting at age 33. Body burden Ra 1.29 μc in 1959. Also has 2.6 μc Cs^{137}. Radiation burns on fingers 25 years after exposure.
Edentulous by age 45. Married 27 years to present. Two children living and well. Past medical history noncontributory, varicose veins only. Present physical exam negative. X-ray and lab. findings normal.

(01-209) Born 1908. Living and in good health. Luminous dial painter for about 3 months between 1926 and 1927 starting at age 17. Body burden Ra 0.006 μc in 1959. No effects demonstrable from radiation 33 years after exposure.
Edentulous by early twenties. Married first time from about 1928 to 1942. Second marriage from about 1945 to 1948. No children or pregnancies. Past medical history shows only hypertension and varicose veins. Tipped brush regularly. Marked luminescence of hair and clothing. Present physical exam shows only hypertension and obesity. X-ray and lab. findings normal.

(01-210) Born 1878. Living and in good health. Physicist in radium clinic for 39 years from 1918 to 1957, starting at age 40. Body burden Ra 0.012 μc in 1959. Slight effects demonstrable from radiation 41 years after exposure.
Edentulous by 1944. Married 54 years to present. One child living and well. "Aplastic anemia" at age 44. Present physical exam negative. X-ray negative. Lab. findings normal except for 1+ albumin, elevated sedimentation rate and blood sugar.

(01-211) Born 1907. Living and in poor health. Received injection of Thorotrast in 1950 at age about 43. Body burden MsTh 0.34 μc in 1959. Slight effects demonstrable from radiation 9 years after exposure.
Teeth in poor condition. Has lost 12 to date. Married 24 years to present, no children. Past medical history of esophageal varices, splenectomy, and splenorenal shunt. Present exam not remarkable except for mild hypertension. X-rays show no evidence of radiation osteitis but do show old Thorotrast injection. Lab. findings normal except for elevated sedimentation rate.

(01-212) Born 1894. Living and in fair health. Received injection of Thorotrast in 1943 at age 49. Body burden MsTh 0.48 μc in 1959. No effects demonstrable from radiation 16 years after exposure.
Teeth in good condition. Has lost 12 to date. Married 39 years to present. Two children living and well. Past medical history of multiple operations starting with ischiorectal abscess in 1943. Present exam negative. X-rays negative for radiation osteitis. Thorotrast deposited in reticuloendothelial system and left lower leg. Lab. findings normal.

(01-213) Born 1894. Living and in poor health. Received injection of Thorotrast in 1934 at age 40. Body burden MsTh 0.145 μc in 1959. No effects demonstrable from radiation 25 years after exposure.
Edentulous before age 20. Married 25 years to present, no children. Aneurysm of neck in 1934. Present physical exam shows weight loss, poor vision right eye, old scoliosis and kyphosis. X-ray and lab. findings normal.

(01-214) Born 1890. Living and in good health. Chemist in radium refinery for about 25 years between 1915 and 1958 starting at age 26. Body burden Ra 0.082 μc in 1959. No effects demonstrable from radiation 44 years after exposure.
Edentulous by age 23. First marriage 1923-1934; one child living and well. Second marriage 1942 to 1956, no children. Past medical history noncontributory. Present physical exam shows only mild hypertension with ? some aortic stenosis, prostatic hypertrophy. X-rays show only cardiac hypertrophy. Lab. findings negative.

(01-215) Born 1898. Living and in good health. Luminous dial painter for 2-1/2 weeks in 1925 at age 27. Body burden Ra 0.000 ± 0.001 μc in 1959. No effects demonstrable from radiation 34 years after exposure.
Edentulous by age 30. Married 36 years to 1954. Three children living and well. No brush tipping. Past medical history shows chronic bronchitis and fracture left ankle 1959. Present physical exam negative. X-ray and lab. findings normal

(01-216) Born 1903. Living and in fair health. Luminous dial painter for 1 month in 1924 at age 20. Body burden Ra 0.000 ± 0.001 μc in 1959. No effects demonstrable from radiation 35 years after exposure.
Teeth in poor condition. Has only two remaining. Married 18 years to present, no children. Tipped brush regularly. Some luminescence of clothing. Hysterectomy 1942, subtotal gastrectomy in 1946 for ulcer. Present exam negative. X-ray and lab. findings within normal limits except for slight osteoporosis of radius, ulna, and humerus.

(01-217) Born 1894. Living and in good health. Luminous dial painting supervisor for 4 years, 1914-1918, starting at age 20; did occasional dial painting until about 1950. Body burden Ra 0.005 μc in 1959. No effect demonstrable from radiation 45 years after exposure.
Teeth in fair condition. Has lost 12 to date. Married 42 years to present, 3 children living and well. Past medical history noncontributory. Denies brush tipping. No luminescence of hair and clothing. Present physical exam negative. X-ray and lab. findings negative.

(01-218) Born 1924. Living and in good health. Chemist in radium laboratory for 1-1/2 years starting in 1950 at age 26. Body burden Ra 0.002 μc in 1959. No effects demonstrable from radiation 9 years after exposure.
Teeth in good condition. Has lost only 5 to date. Married 13 years to present. Two children living and well. Infected parotid gland removed 7 months ago. Present physical exam negative. X-ray and lab. findings normal.

(01-219) Born 1910. Living and in good health. Luminous dial painter for 2 months in 1927 at age 17. Body burden Ra 0.001 μc in 1959. No effects from radiation 32 years after exposure.
Teeth in fairly good condition. Has lost 8 to date. Married 30 years to present. One child living and well. Abdominal operation 10 months ago for ? uterine suspension. Tipped brush occasionally. No luminescence of hair and clothing. Present physical exam noncontributory. X-ray findings negative. Lab. work not done.

(01-220) Born 1907. Living and in good health. Luminous dial painter for 6 months between 1924 and 1925 starting at age 16. Body burden Ra 0.002 μc in 1959. No effects demonstrable from radiation 35 years after exposure.
Teeth in fair condition. Has lost 20 to date. Married 32 years to present. Has one child living and well, two miscarriages. Hysterectomy 1956, cholecystectomy 1957, hiatus hernia 1958. Tipped brush occasionally. No luminescence of hair and clothing. Present physical exam negative except for obesity. X-ray and lab. findings normal.

(01-221) Born 1892. Living and in good health. Supervisor and plant manager in radium refinery for 9 years, 1916-1925, starting at age 24. Body burden Ra 0.011 μc in 1959. No effects demonstrable from radiation 43 years after exposure.
Teeth in good condition. Has lost only 7 to date. Married 34 years, 1922-1956; one child living and well. Second marriage 1958 to present. In 1951 tumor of bladder removed because of malignancy. About 1958 right kidney, ureter, and part of bladder removed because of malignant nodule. Present physical exam shows cataract of right eye, some hypertension, left leg larger than right. X-ray and lab. findings normal.

(01-225) Born 1906. Living and in fair health. Did radium transferring for about 2 years starting in 1931 at age 25. Body burden Ra 0.000 $\pm$ 0.002 μc in 1959. No effects demonstrable from radiation 29 years after exposure.
Edentulous by 1954. Married 33 years to present. One miscarriage. Thyroidectomy 1941, hysterectomy in 1954, laminectomy in 1956. No brush tipping. Some luminescence of hair and clothing. Present physical exam noncontributory. Lab. findings and x-ray negative.

(01-226) Born 1915. Living and in good health. Luminous dial painter for 5 months in 1927 at age 11. Body burden Ra 0.000 ± 0.002 μc in 1959. No effects demonstrable from radiation 32 years after exposure.
Teeth in good condition. Has lost 9 to date. Past medical history shows only obesity. No brush tipping. No luminescence of hair and clothing. Present physical exam reveals only obesity and minimal hypertension. X-ray and lab. findings negative.

(01-227) Born 1908. Living and in good health. Assembled luminous dials and hands for indeterminate period starting in 1950 at age 42. Body burden Ra 0.002 μc in 1959. No effects demonstrable from radiation 9 years after exposure.
Teeth in good condition. Has lost only 1 to date. Past medical history negative. Present physical exam negative. X-ray and lab. findings negative except for slight elevation of B.U.N. and blood sugar.

(01-228) Born 1906. Living and in good health. Luminous dial painter for 2 months starting in 1926 at age 19. Body burden Ra 0.003 μc in 1959. No effects from radiation 34 years after exposure.
Edentulous by 1941. Married 30 years to date. Two children in good health. Past medical history noncontributory. No brush tipping. No luminescence of hair and clothing. Present physical exam shows only moderate obesity. X-ray and lab. findings normal.

(01-229) Born 1903. Living and in good health. Luminous dial painter for about 2 weeks in 1923 at age 19. Body burden Ra 0.008 μc in 1959. No effects demonstrable from radiation 36 years after exposure.
Edentulous by age 45. Married 32 years to present. Three children living and well. Past medical history noncontributory except for ? peptic ulcer. Tipped brush regularly. Some luminescence of hair and clothing. Present physical exam reveals only enlargement of thyroid. X-rays showed questionable areas of radiation osteitis in lateral skull. Lab. findings negative except for mild glycosuria and elevated blood sugar.

(01-230) Born 1913. Living and in fairly good health. Luminous dial painter for 4 months between 1927 and 1928 starting at age 14. Body burden Ra 0.000 ± 0.001 μc in 1959. No effects demonstrable from radiation 32 years after exposure.
Teeth in excellent condition. Has lost none to date. Married, one child living and well. No brush tipping. In 1933 ? tuberculosis, hysterectomy in 1947. Present physical exam negative except for ? thyroid nodule. X-rays negative. Laboratory work not done.

(01-231) Born 1910. Living and in good health. Luminous dial inspector for 1 year 8 months between 1930 and 1931 starting at age 19. Body burden Ra -0.001 ± 0.002 μc in 1959. No effects demonstrable from radiation 29 years after exposure.

Teeth in poor condition. Has only 8 remaining. Married, no children. Past medical history noncontributory. No brush tipping. No luminescence of hair and clothing. Present exam negative. X-ray and lab. findings negative except for hematocrit of 33 percent.

(01-232) Born 1908. Living and in fair health. Drank "Ra water" for ~1 year in 1926. Body burden Ra 0.000 ± 0.001 μc in 1959. No effects demonstrable from radiation 33 years after exposure.
Teeth in fair condition. Has lost 8 to date. Married about 1 year, 1935-1936. No children. Past medical history reveals nephritis, rheumatic heart disease, tuberculoma right lung, several operations on spine, hypothyroidism. Present exam shows moderate hypertension. X-ray and lab. findings negative except for slight elevation of B.U.N.

(01-233) Born 1912. Living and in good health. Luminous dial painter for 2 years 9 months starting in 1927 at age 15. Body burden Ra 0.002 μc in 1959. No effects demonstrable from radiation 32 years after exposure.
Teeth in fairly good condition. Has lost 10 to date. Married 18 years to present. No children. Past medical history shows indigestion, some substernal pain, hemorrhagic cystitis. No brush tipping. Some luminescence of hair and clothing. Present exam negative. X-ray and lab. findings normal.

(01-234) Born 1913. Living and in good health. Luminous dial painter for less than 1 week in 1927 at age 14. Body burden Ra 0.000 ± 0.001 μc in 1959. No effects demonstrable from radiation 32 years after exposure.
Teeth in fair condition. Has lost 7 to date. Married 28 years to present. Two children living and well, one miscarriage. Past medical history shows hysterectomy 1956. No brush tipping. No luminescence of hair and clothing. Present exam negative. X-ray and lab. findings negative.

(01-235) Born 1908. Living and in good health. Luminous dial painter for 2 months in 1925 at age 17. Body burden Ra 0.001 μc in 1959. No effects demonstrable from radiation 34 years after exposure.
Teeth in fair condition. Has lost 12 to date. Past medical history shows hearing loss starting in 1955. Tipped brush regularly. Some luminescence of hair and clothing. Present exam negative except for nodule above isthmus of thyroid. X-ray and lab. findings negative.

(01-237) Born 1907. Living and in good health. Luminous dial painter for about 2 months in 1927 at age 19. Body burden Ra -0.001 ± 0.001 μc in 1959. No effects demonstrable from radiation 32 years after exposure.

Teeth in fair condition. Has lost 10 to date. Married from 1927 to 1947. Five children living and well. Past medical history noncontributory. Present exam negative. X-ray and lab. findings negative.

(01-238) Born 1896. Living and in fair health. Luminous dial painter for about 2 weeks in 1920 at age 23. Body burden Ra 0.001 μc in 1959. No effects demonstrable from radiation 39 years after exposure.
Edentulous by 1956. Married 34 years to present. One child living and well. Past medical history reveals cerebellar degenerative disease. No brush tipping. No luminescence of hair and clothing. Present exam shows ataxia. X-ray and lab findings negative.

(01-244) Born 1901. Living, in mental hospital since 1939. Luminous dial painter for 4 months in 1927 at age 26. Body burden Ra about 0.107 μc in 1960. Married in 1927. Five children. No physical exam, x-ray, or lab. work done.

(01-245) Born in 1920. Living, in apparently good health. Luminous dial painter 7 months in 1957. Body burden Ra about 0.025 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-246) Born in 1885. Living, in apparently good health. Worked in radium clinic 8-9 months in 1915-1916. Body burden Ra about 0.045 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-247) Born 1901. Living and in good health. Radium chemist 2-1/2 years between 1923 and 1926 starting at age 22; also worked almost 8 years, 1930-1937, in radon plant. Body burden Ra 0.005 μc in 1959. Some radiokeratotic areas on hands 36 years after exposure.
Teeth in fair condition. Hast lost about 10 to date. Married 26 years to present, no children. Nonmotile sperm on some examinations. Past medical history shows perinephric abscess in 1924. Present exam shows scars from radiokeratotic areas. X-ray and lab. findings negative.

(01-248) Born 1903. Living and in good health. Luminous dial painter for 8 months in 1917 at age about 14. Body burden Ra 0.041 μc in 1959. No effects from radiation 42 years after exposure.
Teeth in good condition. Has lost 5 to date. Past medical history noncontributory. Tipped brush regularly. No luminescence of hair and clothing. Present physical exam negative. X-ray and lab. findings negative.

(01-249) Born in 1928. Living and in apparently good health. Son of case 01-049. Body burden Ra about 0.033 μc in 1959. Married, 1 child living and well. No physical exam, x-ray, or lab. work done.

(01-250) Born 1894. Living and in good health. Radium chemist for 22 years starting in 1916 at age about 22. Body burden 0.000 ± 0.002 μc in 1959. No effects demonstrable from radiation 43 years after exposure.
Teeth in good condition. Has lost 8 to date. Married 33 years to present. One child living and well. Past medical history noncontributory. Present physical exam negative. X-ray and lab. findings negative.

(01-251) Born about 1889. Living and in fairly good health. Chemist in radium refinery 1912-1915 starting about age 22. Past medical history shows some evidence of heart disease. Body burden about 0.05 μc in 1959. No apparent effects from radiation 47 years after exposure.

(01-252) Born about 1899. Living and in fair health. Luminous dial painter for approximately 3 years, 1917-1919, starting at about age 18. Body burden Ra 0.04 μc in 1959. No apparent effects from radiation 42 years after exposure. Teeth removed in 1954 because of restorative procedures elsewhere in mouth. Past medical history shows headaches, loss of weight, insomnia since 1957 probably due to chronic invalidism of husband. No physical exam or lab. work done. X-rays negative.

(01-253) Born 1898. Living and in good health. Luminous dial painter for 1.5-2 years starting in 1916 or 1917 at about age 18. Body burden Ra about 0.043 μc in 1959. Hysterectomy in 1929, allergic to house dust. No physical exam, x-rays, or lab. work done.

(01-255) Born 1920. Living and in good health. Luminous dial painter for 1 year, 1942-1943, starting at age 22. Body burden Ra 0.002 μc in 1959. No effects demonstrable from radiation 17 years after exposure.
Teeth in good condition. Hast lost only 3 to date. Married 16 years to present. Three children living and well. Past medical history noncontributory. No brush tipping. No luminescence of hair and clothing. Present physical exam negative. X-ray and lab. findings negative.

(01-256) Born 1920. Living and in apparently good health. Physicist in radium laboratory for 4 years, 1949-1952. Body burden Ra about 0.014 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-257) Born about 1885. Living, in poor health. Chemist at radium company for 12 years, 1941-1953. In 1959 had severe heart attack followed by complications resulting in amputation of left leg. Body burden Ra about -0.01 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-258) Born about 1900. Living and in apparently good health. Chemist in radium laboratory intermittently from 1923 to 1944, total exposure time about 16 years. Body burden Ra about 0.011 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-259) Born 1910. Living and in apparently good health. Laboratory worker in radium clinic for 10 years, 1927 to 1937, starting about age 17. Married, 2 children living and well. Body burden Ra about 0.01 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-260) Born 1891. Living and in apparently good health. Drank "Ra water" for 2-3 years between 1918 and 1923 starting at age 27. Body burden Ra about 0.015 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-261) Born 1909. Living and in fair health. Luminous dial painter for about 2 weeks in 1927 at age 17. Body burden Ra -0.001 ± 0.001 μc in 1959. No effects demonstrable from radiation 32 years after exposure.
Teeth in fair condition. Has lost about 8 to date. Married over 30 years to present. Two children living and well. Past medical history shows duodenal ulcer and herniated disc of spine, hay fever. No brush tipping. No luminescence of hair and clothing. Present exam. negative except for obesity. X-ray and lab. findings negative.

(01-262) Born about 1900. Living and in apparently good health. Laboratory worker for short time in 1918 or 1919. Body burden Ra about 0.011 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-263) Born 1897. Living and in good health. Luminous dial painter for about 4 months in 1917 or 1918 starting at about age 19. Body burden Ra about 0.01 μc in 1960. No physical exam, x-ray, or lab. work done.

(01-264) Born 1906. Living and in apparently good health. Repaired luminous aircraft instrument dials for over 15 years starting in 1944 at age 38. Body burden Ra about 1.12 μc in 1960. No physical exam, x-ray, or lab. work done.

(01-265) Born 1902. Living and in good health. Luminous dial painter for 2 weeks starting in 1919 at age 16. Body burden 0.003 μc Ra in 1959. No effects demonstrable from radiation 40 years after exposure.
Teeth in fair condition. Has lost 12 to date. Married 33 years to present. No children. Past medical history noncontributory. No brush tipping. No luminescence of hair and clothing. Present physical exam negative. X-ray and lab. findings negative.

(01-266) Born 1904. Living and in fair health. Luminous dial painter for about 3 weeks in 1923 starting at age 19. Body burden Ra 0.0015 μc in 1960. No effects demonstrable from radiation 37 years after exposure.
Edentulous by 1950. Married 32 years to present. Eight children, one of whom died at birth. Two living are mentally retarded. Past medical history shows mastoidectomy 1922, loss of vision left eye 1931, hysterectomy 1939, bowel resection 1956. Denies brush tipping. Occasional luminescence of hair and clothing. Present exam shows obesity and loss of vision left eye. X-ray and lab. findings negative except for mild leucopenia.

(01-267) Born 1904. Living and in good health. Luminous dial painter for 2-3 years starting about 1925 at about age 21. Tipped brush regularly. Married, 1 child. Body burden Ra 0.030 μc. No physical exam, x-ray, or lab. work done.

(01-268) Born 1901. Living and in poor health. Luminous dial painter for 6 months in 1916 and 6 months in 1918. Body burden Ra 0.11 μc in 1959. Severe effects demonstrable from radiation 43 years after exposure.
At present has only 2 teeth remaining. Married, 2 children living and well. Past medical history shows tumor of sternum developing about 1 year ago. Tipped brush regularly. Some luminescence of hands. Present exam shows recurrence of osteogenic sarcoma of sarcoma following resection. X-rays reveal moderate radiation osteitis, score 13T. Lab. findings negative.

(01-269) Born about 1911. Laboratory worker from 1932 to 1933. Body burden Ra 0.011 μc in 1959. No effects apparent from radiation. No physical exam, x-ray, or lab. work done.

(01-270) Luminous dial painter for 7-8 months in 1943. Tipped brush regularly. Body burden Ra -0.014 μc.in 1959. No physical exam, x-ray, or lab. work done.

(01-271) Born 1899. Luminous dial painter for 1 year 8 months starting in 1917 at age 17. Body burden Ra 0.01 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-272) Born about 1888. Chemist for 2-1/2 years starting in 1956 at age 68. Body burden Ra 0.078 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-273) Born 1907. Living and in good health. Luminous dial painter for about 1 week in 1924. Body burden Ra 0.002 μc in 1959. No effects demonstrable from radiation 35 years after exposure.
Wears partial upper and lower dentures. Married, no children. Past medical history noncontributory. Present exam shows only obesity. X-ray and lab. findings negative.

(01-274) Born 1906. Living and in good health. Luminous dial painter for 1 month in 1922 starting at about age 16. Body burden Ra 0.03 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-275) Chemist. No additional information available at present.

(01-276) Born about 1930. Living and in fair health. Laboratory worker for about 4 years starting in 1945 at age 15. Body burden Ra 0.06 μc 1960. Severe arthritis. No physical exam, x-ray, or lab. work done.

(01-278) Born about 1904. Laboratory worker about 1925. Body burden Ra 0.035 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-279) Born 1901. Laboratory worker for 20 years, 1928-1948, starting about age 27. Body burden Ra 0.021 μc in 1960. No physical exam, x-ray, or lab. work done.

(01-280) Born 1905. Living and in good health. Luminous dial painter for 2 months in 1926 at age 20. Body burden Ra 0.000 ± 0.001 μc in 1960. No effects demonstrable from radiation 34 years after exposure.
Edentulous by 1943. Married 33 years to present. Three children, one of whom died at age 22 months. Past medical history shows thyroidectomy 1940, hysterectomy 1951, cholecystectomy 1954. No brush tipping or luminescence of hair and clothing. Present exam reveals nodule in right anterior neck, and small mass to right of periurethral orifice. X-rays negative. Lab. findings normal except for 4+ glycosuria and elevated blood sugar.

(01-282) Born 1893. Living and in good health. Chemist from 1916-1919 starting at age 23. Body burden 0.055 μc in 1959. No effects demonstrable from radiation 43 years after exposure.
Has lost only 4-5 teeth to date. Married 37 years to present. Two children living and well. Past medical history noncontributory. Present exam shows slight hypertension and benign prostatic hypertrophy. X-ray and lab. findings negative.

(01-283) Born 1895. Living and in good health. Filled light pulls with luminous material for 1 year, 1917-1918, starting at age 22. Body burden Ra 0.003 μc in 1960. No effects demonstrable from radiation 43 years after exposure.
Has lost 8-9 teeth. Married 1915-1946. Seven children, two of whom died in infancy. No luminescence of hair and clothing. Past medical history varicose veins and dermatitis left ankle since 1930, cholecystectomy 1931, arthritis since 1957. Present exam negative. X-ray and lab. findings negative.

(01-284) Born 1892. Living and in good health. Chemist 1943-1947 starting at age 51. Body burden Ra 0.005 μc in 1959. No effects demonstrable from radiation 16 years after exposure.
Has lost only 5 teeth. Married 45 years to present, 1 child living and well. Past medical history of coronary thrombosis in 1955. Present exam shows moderate hypertension and minimal prostatic hypertrophy X-ray and lab. findings negative except for slightly elevated wbc and sed. rate.

(01-285) Born 1900. Living and in good health. Luminous dial painter for 1 week in 1923. Body burden Ra 0.004 μc in 1959. No effects demonstrable from radiation 37 years after exposure.
Has lost all but 4 lower teeth. Married 40 years to present. Three children living and well. Past medical history noncontributory. Denies brush tipping. No luminescence of hands and clothing. Present exam negative. X-ray and lab. findings negative except for elevated blood sugar.

(01-286) Born about 1918. Living and in good health. Received Thorotrast injection in 1942, 1943. at which time material leaked out of needle into neck tissues. Severe pain in 1958, neck resection 1960. Body burden MsTh 0.077 μc. No information available at present on physical exam, x-ray, or lab. findings.

(01-287) Born 1908. Living and in good health. Luminous dial painter for 7 months 1927-1928 starting at age 19. Body burden Ra 0.005 μc in 1960. No effects demonstrable from radiation 33 years after exposure.
Edentulous by 1957. Married 21 years to present. Two children living and well. Past medical history shows diabetes in 1957. No brush tipping. Luminescence of hair and clothing. Present exam negative. X-ray and lab. findings negative except for glycosuria and moderately elevated blood sugar.

(01-288) Born 1896. Living and in good health. Luminous dial painter for 3 weeks in 1926. Body burden Ra 0.002 μc in 1960. No effects demonstrable from radiation 34 years after exposure.
Edentulous by 1931. Married 39 years to present. Four children, one of whom died in childhood. Past medical history shows hypertension. Tipped brush regularly. No luminescence of hair and clothing. Present exam shows only hypertension. X-rays show questionable minimal changes in right humerus. Lab. findings negative except for moderately elevated blood sugar.

(01-289) Born 1899. Living and in good health. Luminous dial painter for 1-1/2 years 1919-1921 starting at age 19. Body burden Ra 0.006 μc in 1960. No effects demonstrable from radiation 41 years after exposure.

Has 8 teeth remaining at present. First marriage 1920-1940. Three children living and well, two miscarriages. Second marriage 1943 to present. Past medical history shows only hypertension for many years. Tipped brush regularly. No luminescence of hair and clothing. Present exam reveals moderate hypertension. X-ray and lab. findings negative.

(01-290) Born 1906. Living and in poor health. Received Thorotrast injection at some time in past. Painted luminous dials summers between 1920 and 1924 starting at age 14. Body burden Ra 0.021 μc, MsTh 0.025 μc in 1960. No effects demonstrable from radiation.
Has 21 teeth remaining at present. Married 35 years to date. Two children living and well. Past medical history reveals multiplicity of operations and illnesses. Present exam negative. X-ray and lab. findings negative.

(01-291) Born 1910. Living and in poor health. Luminous dial painter for 4 months in 1928 at age 17. Body burden Ra 0.005 μc in 1960. No effects demonstrable from radiation 32 years after exposure.
Edentulous by 1931. Married 1929-1959. One child living and well. Past medical history shows diabetes, psoriasis, cholecystectomy 1950, angina pectoris 1959. No brush tipping. Luminescence of hair and clothing. Present exam reveals mild diabetes, angina pectoris. X-rays negative. Lab. findings normal except for 2+ glycosuria.

(01-292) Born about 1903. Died 1930. Luminous dial painter 1919-1922 starting at about age 16. Body burden Ra 2.0 μc. Severe effects demonstrable from radiation 11 years after exposure. Married, 2 children. Autopsy confirmed diagnosis of two primary osteogenic sarcomas, right ilium and right orbit.

(01-293) Born 1911. Living and in good health. Luminous dial painter for about 3 months in 1924. Body burden Ra 0.002 μc in 1960. No effects demonstrable from radiation 36 years after exposure.
Has lost about 14 teeth to present. Married 28 years. No pregnancies. Past medical history of hysterectomy in 1957. No brush tipping. Present exam shows marked obesity, ? glandular dysfunction. X-ray and lab. findings negative except for slightly elevated blood sugar.

(01-294) Born 1912. Living and in good health. Luminous dial painter for 1 year, 1927-1928, starting at age 15. Body burden Ra 0.003 μc in 1960. No effects demonstrable from radiation 33 years after exposure.
Has only 4 teeth remaining at present. Married 32 years to date. One child who is mentally retarded. Past medical history shows cholecystectomy 1930, hysterectomy 1936. No brush tipping or luminescence of hair and clothing. Present exam essentially negative. X-ray and lab. findings negative.

(01-295) Born 1911. Living and in good health. Luminous dial painter for 2-1/2 months in 1927 at age 15. Body burden Ra 0.000 ± 0.001 μc in 1960. No effects demonstrable from radiation 33 years after exposure.
Has only 4 teeth remaining. Married 18 years to present. Four children living and well. Past medical history of hysterectomy in 1953. No brush tipping or luminescence of hair and clothing. Present exam shows varicose veins, ? hypothyroidism. X-ray and lab. findings negative.

(01-296) Born 1908. Living and in good health. Luminous dial painter for 1 month in 1927 at age 19. Body burden Ra 0.000 ± 0.001 μc in 1960. No effects demonstrable from radiation 33 years after exposure.
Has lost 14 teeth to present. Married 25 years to date. Two children living and well. Past medical history noncontributory. No brush tipping or luminescence of hair and clothing. Present exam, x-ray, and lab. work negative.

(01-297) Born 1901. Living and in good health. Luminous dial painter for 5 months between 1921 and 1923 starting at age 19. Body burden Ra 0.016 μc in 1960. Minimal effects demonstrable from radiation 39 years after exposure.
Has only 2 teeth left at present. First marriage in 1918 last 6 weeks. Second marriage 1944 to 1958. No pregnancies by either marriage. Past medical history shows chronic otitis media, two nervous breakdowns between 1950 and 1960. Tipped brush regularly. No luminescence of hair and clothing. Present exam reveals moderate bilateral deafness, loud apical systolic murmur. X-rays show minimal radiation osteitis, score 7. Lab. findings normal.

(01-299) Born 1896. Living and in apparently good health. Luminous dial painter between 1917 and 1918 starting at about age 21. Body burden Ra 0.02 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-301) Born 1904. Living and in good health. Had "Ra" injections in 1926, at age 22. Body burden Ra 0.03 μc in 1959. Past medical history shows low blood count. No physical exam, x-ray, or lab. work done.

(01-302) Born about 1900. Living and in fair health. Received $RaCl_2$ injections in 1928, total 400 μc. Body burden Ra 0.56 μc in 1960. Past medical history shows fracture of femur which failed to heal after multiple bone grafts. Disarticulation of hip following infection. No physical exam, x-rays, or lab. work done.

(01-303) Born 1919. Living and in good health. Luminous dial painter 1940-2 starting at about age 20. Body burden 0.104 μc in 1959. No physical exam, x-ray, or lab. work done.

(01-305) Born 1925. Chemist in radium refinery 1947 to present. Body burden Ra 0.47 μc in 1960. No physical exam, x-ray, or lab. work done.

(01-306) Chemist in radium refinery. Body burden 0.086 μc in 1960. No physical exam, x-ray, or lab. work done.

(01-307) Chemist in radium refinery. Body burden 0.02 μc in 1960. No physical exam, x-ray, or lab. work done.

(03-003) Body burden Ra 0.65 μc in 1959. Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(03-004) Body burden Ra -0.002 μc in 1959. Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(03-005) Body burden 0.54 μc Ra in 1959. Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(03-006) Body burden 0.47 μc Ra in 1959. Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(09-001) Body burden Ra 0.007 μc in 1959. Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(09-002) Body burden Ra 0.010 μc in 1959. Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(09-003) Body burden Ra 0.41 μc in 1959. Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(I.Da.) See case (I.Da.) M.I.T. progress report May 1958.

(I.Ja.) See case (I.Ja.) M.I.T. progress report May 1958.

11. Skeletal Survey for Radiation Effects

During the past year the scope of the skeletal survey for detection of changes caused by internally deposited radioactive substances has been enlarged. A very complete series of films including the entire skeleton, with painstaking attention to technical factors, is now made. These should, in the next few years, provide a substantial library of cases showing the entire spectrum of radiation changes from those that are barely detectable to those that are far advanced. These will be stored at M.I.T. under suitable conditions and be available for study by anyone working on the project.

Joint film interpretation sessions have been held with the Argonne and New Jersey groups, and it has been found that criteria for evaluating films are in good agreement between the three groups. At a meeting in Chicago in February 1960, a scoring system was agreed upon (see Fig. 1). Its adoption by all three groups will make it possible to classify any case by a numerical system into negative, minimal, mild, moderate, or advanced radiation change groups. Criteria for coding are the same as those long in use at the Argonne Cancer Research Hospital.

Small areas of bone resorption and minimal alterations in trabecular pattern of bone remain the earliest recognizable abnormalities. These changes have been detected with body burdens as small as 0.016 μc Ra. A body burden of 0.11 μc is the least associated with a malignant tumor of bone in our series which now totals >300 cases. A pathological fracture has occurred with a body burden as small as 0.083 μc, but in each of these cases the MsTh/Ra ratio was large and the major radiation dose was delivered by MsTh and its decay products rather than by the small amount of Ra present.

It is believed that future activities should consist of enlarging the film library by the addition of cases, particularly those with body burdens in and below the range of those who at present show the most minimal changes from normal. It is in this group that abnormalities not recognized at present as being due to radiation may in the future be identified as such. Some thought should be given to acquiring bone surveys on persons of comparable age who have had no occupational exposure to radioactive substances. In this way a better understanding of the range of normal insofar as changes due to aging alone can be obtained.

Since occupational exposures to radium will probably not occur again, and since most of those available for study are in the older age group, as

Massachusetts Institute of Technology
Radioactivity Center

BONE SURVEY FOR RADIATION EFFECTS

CC # _____
Name _____
Date _____

Present age _____
Age at 1st exposure _____
Date of exposure _____
Type of exposure _____
Date of films _____
Body burden _____

AREA	SCORE
1. Skull -- vault	
2. Skull -- base, including facial bones	
3. Mandible and teeth	
4. Cervical spine	
5. Rib cage, including sternum and chest	
6. Dorsal spine	
7. Lumbar spine	
8. Pelvis	
9. Left femur	
10. Right femur	
11. Left tibia and fibula	
12. Right tibia and fibula	
13. Left foot and ankle	
14. Right foot and ankle	
15. Left humerus, scapula, and clavicle	
16. Right humerus, scapula, and clavicle	
17. Left radius and ulna	
18. Right radius and ulna	
19. Left hand and wrist	
20. Right hand and wrist	
TOTAL	

Impression _____

Other findings (clinical, etc.) _____

_____

_____

_____

Note: The most advanced lesion determines the score for each area

Criteria for coding radiographic changes with radium deposition

o No departure from normal

± Questionable, barely detectable changes such as slight coarsening of trabeculation

\+ Minimal areas of bone resorption (equal to or less than 10 mm. in longest diameter) in the cortex of long or flat bone, or Isolated areas of patchy bone sclerosis, or Definite coarsening of trabeculation

++ Large punched-out areas of bone resorption (greater than 10 mm. in longest diameter) in flat or long bones, or Lesions of + severity, plus (a) some areas of bone sclerosis or (b) definite coarsening of trabeculation

+++ Extensive changes of ++ severity plus (a) changes in trabecular pattern or (b) areas of bone sclerosis

++++ Large areas of aseptic necrosis and/or pathological fracture

+++++ Malignant changes

General Impression: Negative for changes typical of radium deposition

Minimal (1 - 8)
Mild (9 - 16) changes typical of
Moderate (17 - 25) radium deposition
Advanced (25 +)

Malignant changes associated with radium deposition

Note: A score of ++++ or +++++ in one area makes case advanced irrespective of total score

T = tumor, F = path. fracture, N = normal, M = miscellaneous

many as possible should be examined in the next few years. They constitute a limited and irreplaceable reservoir for the study of radiation changes in humans. If a complete skeletal survey is obtained, and a permanent film library maintained, abnormalities found later at autopsy or biopsy can be correlated with changes seen during life on the films.

12. Epidemiological Conclusions from Ra-MsTh Studies

The goal of this whole project is the correlation of body burden of Ra and MsTh, incidence of various effects such as tumors and fractures, age at exposure and at occurrence of effect, etc. A very rough picture, based on a few cases, has been available for many years. A picture having some statistically quantifiable validity is only now beginning to emerge. During the year, three meetings of the U. S. laboratories engaged in these studies have taken place. In preparation for these meetings an effort has been made to systematize and to interpret the existing M.I.T. data. Several reports, internal memoranda, and tables have been compiled and have been circulated among the three working laboratories. These are not available for publication or general distribution at the present time. Ideally, a complete review of the data, accompanied by speculation as to interpretation, should be based on the total pool of data from all laboratories, and the time for such a synthesis has not been considered ripe.

(E.W.Backofen, S.D.Clark, R.A.Dudley, J.E.Gary, D.R.Kuchta, M.G. Paulsen, M.M.Shanahan, M.Tavla, F.I.Visalli)

13. Dial Paint Sample Analysis

The MsTh/Ra ratios of the old dial paint samples listed in Table 15 have been determined. All the sources were sealed in glass tubes which were counted at a distance of about 20-50 cm from the 8" x 4" NaI crystal, on its axis. The MsTh activity was calculated from the RdTh activity, which in turn was measured via the ThC" (Tl^{208}) 2.62-Mev γ. The Ra activity was measured via the RaC (Bi^{214}) 1.76-Mev γ. The MsTh/Ra ratio was determined as follows: An NBS Ra standard and an Eimer and Amend aged Th standard were successively counted at a typical distance from the crystal. The cpm/μc

Table 15. Results of γ measurement of MsTh/Ra ratio in dial paints

sample no.	RdTh/Ra (1960)	MsTh/Ra (1918)*	sample origin**
310	$(-1.4 \pm 5.6) \times 10^{-4}$	-0.008 ± 0.0031	NC-4 compass, 1919
311	$(8.2 \pm 5.6) \times 10^{-4}$	0.045 ± 0.031	DH-4 temperature gauge, 1918
312	$(9.6 \pm 5.7) \times 10^{-4}$	0.053 ± 0.031	DH-4 temperature gauge, 1918
313	$(8.4 \pm 5.6) \times 10^{-4}$	0.046 ± 0.031	DH-4 tachometer, 1918
314	$(1.5 \pm 5.8) \times 10^{-4}$	0.007 ± 0.032	DH-4 altimeter, 1918
315	$(8.2 \pm 12) \times 10^{-4}$	0.045 ± 0.066	DH-4 bank indicator, 1918
316	$(4.2 \pm 5.1) \times 10^{-4}$	0.023 ± 0.028	DH-4 bank indicator, 1918
317	(too low activity for γ measurement)		DH-4 altimeter, 1918
318	$(1.2 \pm 5.6) \times 10^{-4}$	0.006 ± 0.031	DH-4 oil pressure gauge, 1918
319	$(5.7 \pm 5.7) \times 10^{-4}$	0.031 ± 0.031	F5L oil pressure gauge, 1919
320	$(-2.5 \pm 5) \times 10^{-4}$	-0.014 ± 0.03	F5L tachometer, 1919
321	$(6.7 \pm 5.3) \times 10^{-4}$	0.04 ± 0.03	F5L altimeter, 1919
322	$(3.7 \pm 4.5) \times 10^{-4}$	0.021 ± 0.025	DH-4 compass, 1918

* Assumes MsTh half-period = 6.7 years. If half-period = 5.7 years, all values in this column should be doubled.

** We wish to thank especially Mr. Steven Beers of the Smithsonian Institution, Washington, D.C.

was measured for the Ra standard in a narrow energy band at 1.76 and 2.62 Mev, and for the Th standard at 2.62 Mev only. (The MsTh activity in the dial paint samples contributed negligibly to the counting rate of these samples at 1.76 Mev.) The Ra counting rate at 2.62 Mev constituted the chief "background" at this energy and considerable care was required in subtracting these counts out to leave the legitimate ThC" counts. The 2.6-Mev Ra counts evidently appear through 3 alternative routes:

(1) Legitimate counts from Ra series γ rays at 2.6 Mev or greater.

(2) Coincidence in the crystal of coincident γ rays in the Ra series.

(3) Spurious pile-up in the crystal of noncoincident Ra series γ rays as a result of the counting rate.

These 3 sources of 2.6-Mev pulses are each affected differently by the variables of source-crystal distance and source activity requiring the establishment of curves giving the relative counting rates of the 2.6- and 1.76-Mev pulses for conditions pertinent to the various dial paint measurements.

As a check on the procedure a weak Th standard was counted in the presence of the Ra standard. The actual ratio of "effective activities" (allowing for a shorter measurement on the Th standard to simulate a weaker source) was RdTh/Ra = 19×10^{-4}; the measured ratio was $(16 \pm 5) \times 10^{-4}$.

A second check was made by dissolving one of the dial paint sources (M.I.T. No. 310) and deemanating Tn in the usual manner. This was considered essential since the possibility of MsTh in the Ra standards could not be excluded. Were MsTh in the Ra standards, contrary to our assumption, too many 2.6-Mev counts would have been subtracted out from the dial paint data as Ra "background", with a consequent erroneously low MsTh/Ra ratio in the paint. The Tn measurement showed about 1.7×10^{-6} μc RdTh in the 1.5-μc Ra, as compared with the γ result of $(-2 \pm 8) \times 10^{-4}$ μc RdTh in the 1.5-μc Ra. This Tn result is incidentally interesting in 4 respects:

(1) It shows that our Ra standard has less than about 6×10^{-4} μc RdTh/μc Ra, as had been assumed.

(2) It confirms that the γ rays of energy 2.6 Mev or greater which were emitted from this dial paint sample were not from ThC", and are presumably therefore from the Ra series.

(3) It demonstrates an exceedingly low MsTh/Ra ratio in the dial paint (even in $\sim$1918 when the sources were prepared the ratio was about 1×10^{-4}).

(4) It illustrates the great discrimination between MsTh and Ra of which the Tn deemanation system is capable (1 $\mu\mu$c RdTh could easily be

measured in the presence of 1 mc Ra).

All MsTh/Ra ratios calculate to be less than 0.06 as of 1918, and none has been proved to have a finite value except No. 310, for which the Tn measurement allowed greater sensitivity.

(R. A. Dudley)

14. Central Catalog

The principal effort during the coming year is being placed on the recording of data on punched cards and the distribution thereof, and on the improved maintenance of physical security of records as noted in the May 1959 annual progress report.

Since May, a small initial distribution of cards on Argonne and M.I.T. cases has been made to Argonne National Laboratory and to the New Jersey Department of Health group. Agreement has been reached with Argonne for the registration of names of cases. This will avoid duplication of effort in finding persons exposed to radioactive materials.

Microfilming and copying of records and x-rays consistent with maintaining the best possible physical security has already been started. This will continue as rapidly as the budget permits.

Serial prefix numbers 07 and 08 have been assigned to the study of Swiss dial painters which is now being started by Professor Pierre Wenger. The number 07 is to be used for cases studied at Geneva, the number 08 for those studied at Zurich.

Serial prefix number 09 has been assigned to the cases originating in the Standard Chemical Company at Pittsburgh, and being studied cooperatively by M.I.T. and Argonne.

The U. S. Public Health Service, Division of Radiological Health, has expressed official interest in this compilation, and has been added to the roster of depositories.

(M. M. Shanahan)

15. Dosimetry of Spent Therapeutic Gold Radon Seeds

The intensity, spatial distribution, and spectral distribution of the residual radiation emitted by 6 examples of 10- to 20-year-old therapeutic radon gold seeds has been remeasured. Each seed is made from 0.67-mm O.D.

gold capillary tubing having a 5 mil (250 mg/cm^2) wall thickness and cut to a length of about 3 mm by crimping-and-cutting pliers. Each seed originally contained 1 to 1.5 mc Rn, and in the absence of initial radon leakage would contain 0.3 to 0.4 μc of RaD (half-period, 20 years) 20 years after preparation, and the same activity of RaE and RaF (polonium).

The external photon radiation was measured with a 1-3/4 in x 2 in NaI(Tl) scintillation spectrometer, as well as with a Lauritsen electroscope. The photon spectrum is a prominent line at 78 kev superimposed on a broad continuous spectrum extending from 0 to 1.17 Mev which has a broad maximum between 150 and 200 kev, and very little intensity above 500 kev. These radiations are identified as the K_α x-rays of gold produced by β rays of RaE and α rays of RaF superimposed on the continuous bremsstrahlung produced by the absorption of the RaE β rays in gold, all of these radiations being filtered through gold during emergence from the seed. The photon exposure dose in air at 1 cm distance is about 0.3 milliroentgen per day, or about the same as the total of cosmic and local γ radiation at sea level. But the photon radiation dose close to the seed (~1 mm) will be of the order of 100 times greater than the dose at 1 cm, hence of the order of 10 r/year.

The range of the RaE β rays is expected to be of the order of 600 mg/cm^2, and their effective absorption coefficient about 18 cm^2/g, in gold. Hence, several percent of the β radiation can escape through the cylindrical walls. Clear qualitative evidence that the major external dose was due to β rays was found by absorption measurements using a Lauritsen (Henson Instrument Co.) electroscope having a wall thickness of 137 mg Al/cm^2. The β-ray dose rate at the surface of the seeds was then measured using quantitative autoradiographic methods, with calibrated Sr^{90}-Y^{90} plaques as standard sources. The β-ray dose rate was found to be much greater at the crimped ends of the seeds than in the center, presumably as a result of the reduction in gold thickness caused by the crimping. Dose rates differed considerably between seeds. Four seeds (each 1.5 mc Rn in 1939) from one patient ranged from 5 to 20 rad per day at the seed ends; two seeds (each 1.0 mc Rn in 1947) from another patient were in the neighborhood of 1 rad/day at the seed ends. Thus, the β-ray dose to cells in contact with the seed ends would be of the order of 400 to 4000 rads/year, or about 100 times as large as the photon dose.

These experiments have been done on only 6 old radon seeds, removed from two patients and sent to M.I.T. on 9 October 1958 by Dr. John B. Graham, (Dept. of Gynecology, Roswell Park Memorial Institute, Buffalo) who called

for help when his physicist found external radiation but could not identify or quantify it. Professor H. E. Johns at the University of Toronto Dept. of Biophysics independently studied other old radon seeds sent by Dr. Graham from the same patients and reported an exposure dose of photons about 3 times larger than our observations, but apparently missed the β rays because of instrumentation.

Dr. Graham has "recently encountered one vesico-cervical fistula apparently due to radiation 19 years, and three recurrences of tumor 12, 20, and 21 years after the insertion of radon seeds in the treatment of patients with cancer of the uterine cervix" and has found "cytologic changes in the vaginal smear that suggest some continued biologic effect of the radiation".

Possibly this is an area involving low-level, chronic irradiation of humans which should be investigated by medical and statistical people in the hope of determining whether or not there is any true effect attributable to local radiation in the domain of 5 to 50 rad per year from photons and the order of 1000 rads per year from β rays.

(R. D. Evans and R. A. Dudley)

B. Nuclear Physics

1. Low Level Studies in the M.I.T. Cobafac

a. Background studies

The γ-ray background of the M.I.T. COBAFAC has been measured with a 4" x 4" NaI(Tl) crystal coupled to a 5" 6364 Dumont photomultiplier tube, an 8" x 4" NaI(Tl) crystal with 3 selected 3" 6363 Dumont photomultiplier tubes of low background tube base, and with a 4" x 4" NaI(Tl) crystal with a matched window and a 3" 6363 Dumont photomultiplier tube of low background base. The crystals with their respective phototubes were suspended on a track which could be positioned anywhere in the room and a telescoping assembly enabling the crystal to be tilted in the other two degrees of freedom.

The standard position for total body chair measurements as explained in Sec. A2 of this report is used throughout the background measurements with the same calibration of 75 channels per Mev and counting periods of ~1000 minutes.

The following table shows the background and resolutions obtained with the above crystals and photomultiplier tubes.

details	4" x 4" NaI(Tl) crystal with 5" 6364 Dumont photomultiplier tube	4" x 4" NaI(Tl) crystal with selected 3" 6363 photomultiplier tube	8" x 4" NaI(Tl) crystal with 3 selected 3" 6363 photomultiplier tubes
background (0.2-2.0 Mev)	330 cpm	310 cpm	1000 cpm
pulse-height resolution Cs^{137} (0.662 Mev)	12.8 percent	10.4 percent	9.6 percent
Na^{22} (1.276 Mev)	11.1 percent	8.9 percent	7.2 percent

b. Measurement of M.I.T. personnel

During the last ten months, 45 more subjects from the cyclotron, reactor, and other isotope facilities had total body radioactivity measurements made in the M.I.T. COBAFAC, all indicating normal amounts of K^{40} and Cs^{137}.

The Zn^{65} body burden of subject (F. F.) measured last year and reported to be 0.07 μc should be corrected to be 0.025 μc.

One individual was measured for Co^{60} body burden after a Co^{60} spill. This person was found to contain 0.79 μc Co^{60} on 26 Jan 1960, predominantly located in the lungs. On 31 March 1960 the burden was 0.27 μc indicating a loss of two-thirds of the burden in 75 days. Although premature, these results lead to a biological half-period of ~50 days.

(K. Shivanandan)

2. Mössbauer Scattering

During the initial general interest in the Mössbauer effect in which the Co^{57}(14-kev γ)-Fe^{57} system was widely used, a 1 mc source of Co^{57} was procured which was unfortunately equally active with Co^{56}. The purpose was to try to observe the Mossbauer effect more distinctly by looking for the 14.4-kev γ ray scattered from a thin Fe scatterer, rather than the usual experiment in which anomalously large absorption from a thin absorber is observed. With a scintillation counter completely shielded from the primary γ beam, seeing only the thin scatterer, it was believed that the base counting rate from higher energy γ ray(s) could be very much lowered so that the Mössbauer effect would stand out as a larger percentage effect. The possibility was also considered of using coincidence counting to further reduce this background by gating on the shielded counter only by the 123-kev γ, the partner of the 14-kev γ in cascade, detected by a counter close to the source.

Unfortunately the increased activity of the source due to the Co^{56} contamination ruled out the coincidence technique with the relatively slow coincidence units immediately available. In observing the scattered radiation one is working at a ~15:1 disadvantage not encountered in an absorption experiment, namely, the internal conversion coefficient of the transition. These difficulties reduced the experiment to the point where the effect observed was the order of 0.7 ± 0.3 percent. These percentages refer to counting rates observed with the source and scatterer at rest as opposed to when the source and scatterer are in relative motion and the resonance scattering condition is destroyed. The scatterer used in this observation was a piece of 1-mil Fe foil. Very much thinner scatterers made by evaporation of pure iron onto 1/2-mil mylar were tried; however, no effect was

observed during their use.

No immediate action is planned for this experiment, although as time and the Co^{56} in the source passes, further studies may be undertaken.

(H. W. Kraner)

3. α-ray Spectroscopy

Several solid state (silicon, diffused p-n junction) α-particle detectors have been obtained and tested, and these suggest several experiments formerly of great difficulty with other types of counters.

The first experiment takes advantage of both the excellent resolution of these counters and their reputed fast rise time. It is planned to set up a conventional fast-slow coincidence arrangement to measure by delayed coincidence the lifetimes of low-lying rotational states in even-A transuranic nuclides. Nuclides well above A = 208 are considered to be strongly deformed, excellent examples of the collective model. As such, their first two (or three) excited states are members of the first rotational band. The general systematics of first rotational levels indicate that the lifetimes should be about $1 \pm 0.8 \times 10^{-9}$ sec, which may be resolved by fast delayed coincidence. An examination of several of these states is planned to establish the uniformity predicted by previous studies of the systematics of collective nuclear motion.

At present a fast low-noise preamplifier or amplifier is being developed to be used in the fast leg of the α detector. Considerable problems are posed here due to the low levels of the output signals from the detectors and the bandwidth-noise consideration of amplifiers in general.

The second type of experiment suggested by the solid state detectors utilizes only their excellent resolution and could be strictly termed α-ray spectroscopy. Several decay schemes, particularly of odd-A nuclides in the transuranic region, are available for further study with α-γ angular correlation first in mind. To gain experience, since the source is readily available, the ThC (Bi^{212}) decay (~ 70 percent to a 40-kev level in Tl^{208}) has been observed. Previous angular correlation work indicates the angular momenta and parities of the levels involved are (1-), (4-), (5+) and it should be possible to better identify the α-γ angular distribution responsible for this assignment.

(W. R. Neal, W. C. Cobb, H. W. Kraner)

4. Thick α-Source Counting

Recently, attention has been drawn to the shape of the differential pulse-height spectrum from thick plane α-particle sources. When an α emitter is distributed homogeneously throughout a material, one observes, at a surface, α's emitted from depths extending to the maximum range of α particles in the material. It is not immediately obvious what the energy spectrum of these emanating α particles should be. However, it has been found possible to derive the spectrum shape analytically and experimental verification is abundant. Moreover, the spectrum exhibits a sharp cut-off at the α-ray energy so that the thick source spectra could be used for quantitative measurement of α activity. This feature would save considerable preparation time in routine assay of α activities.

Finney and Evans[1] showed in 1935 that the integral range spectrum from a homogeneous thick α source emitting α's of energy E_α is

$$N(\rho) = \frac{N(R - \rho)}{4} \quad \frac{\alpha}{\text{sec-cm}^2} \tag{1}$$

where N = specific activity of α emitter α/sec-cm^3

R = maximum range of α particle in material

ρ = residual range of α's emerging from surface

Equation (1) can be put into an energy representation simply through the range-energy relationships

$$N(E) = \frac{N}{4}\left[R(E_\alpha) - \rho(E)\right] \tag{2}$$

The differential spectrum is simply the derivative of the above, treating $R(E_\alpha)$ as a constant for a particular source

$$\frac{dN(E)}{dE}dE = \frac{N}{4} \frac{1}{-\left[dE/d\rho(E)\right]}dE \tag{3}$$

The above result was also obtained by Beique,[2] who has attempted to construct the pulse-height spectrum from normal bone due to the naturally occurring α emitters.

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1. G. D. Finney and R. D. Evans, Phys. Rev. 48, 503 (1935).
2. R. A. Beique, Ph.D. thesis, M.I.T., 1958, unpublished.

As the specific ionization decreases at the higher energies (E > 2-3 Mev), the pulse-height spectrum rises until the maximum α energy E_α is reached. The spectrum then cuts off sharply and permits a good determination of the α energy.

This spectrum has been verified experimentally with a number of thick sources: ThO_2 containing the complete Th series, U_3O_8 having two main α groups at 4.19 and 4.77 Mev, and a thick Po α source of 5.3 Mev. The observed spectra shapes agree qualitatively very well with that derived in Eq. (3) when the specific ionization for air, for example, is used. The discrepancies between theory and experiment that occur are expected as the specific ionization in a much higher Z compound should be used. Work is continuing on the more precise fit of the data with Eq. (3), using better range-energy data.

The α-particle spectrometer used in this work has been a 5-mm diameter semiconductor detector, capable of between 1 and 2 percent energy resolution of ~6-Mev α particles. The natural background of the detectors themselves appears to be extremely low, and it is not expected to interfere with the measurement of very low level samples. Although the small sensitive area makes low activity counting even more difficult, the ease and simplicity of their use is definitely a compensating feature. It is planned to pursue this study using an improved larger area (2 cm^2) detector now on order.

(H. W. Kraner)

5. Bremsstrahlung Produced by Continuous β-ray Emitters

The shape and absolute intensity of the bremsstrahlung spectra produced by β-ray sources of S^{35}, Tl^{204}, Sr^{90}-Y^{90}, P^{32}, and separated Y^{90} in absorbers generally of carbon, aluminum, steel, tin, and lead have been measured using cylindrical geometry. Because of the absorption in the β-ray sources, very little information was obtained from the S^{35} measurements, and the Tl^{204} results required extra processing.

The observed pulse-height distributions were converted to photon distribution using a 53 by 53 response matrix with variable channel width. A matrix type self-absorption correction which includes the effects of scattering, was used for each measurement. The activity of the β-ray source was found using a 4π flow-type β counter operated in the proportional region.

The spectra, corrected and normalized in this fashion, were compared with the thick-target spectra calculated by integrations of basic thin-target

cross sections. The Born-approximation cross sections, corrected for screening and multiplied by the Elwert factor to approximate coulomb and high frequency limit correcting, were used as the basis for the integration. An attempt to base the calculation on empirical thin-target cross section measurements was unsatisfactory because of the lack of such measurements. Another approach based on the exponential character of β-ray absorption was developed and found to give a good approximation of the observed spectra. An improvement of two analytical approximations to the bremsstrahlung spectra was obtained; these approximations give easily calculable results when great accuracy is not required.

The observed bremsstrahlung spectra give higher values than the calculated spectra, the differences becoming larger for higher atomic number radiators and for higher photon energies. The results show less difference from the theory than previously reported, both in regard to spectral shape and intensity.

The measured total energy radiated as bremsstrahlung agrees with the Born-approximation values, mainly because the intensity is peaked at the low energy end of the spectrum where the theory is valid.

By extrapolation of the measured values, the internal bremsstrahlung spectra of P^{32} and Y^{90} were found, and they showed general agreement with the shape and intensity of the theoretical spectra.

(J. L. Bear)

6. Bremsstrahlung from Monoenergetic Electrons

A study is under way on the bremsstrahlung (continuous spectrum x-rays) emitted by monoenergetic electrons in passing through thin sheets of matter. It is intended that electrons of 10 to 100 kev be directed from an electron gun onto targets of 6 or 8 different elements having well-spaced atomic number. The emitted x-rays will then be characterized as to intensity, energy, and direction using a NaI crystal detector. Results from the experiments will be compared with theory, whose accuracy is not good in the mildly relativistic electron energy range.

(A. A. O'Dell, Jr.)

7. MsTh Half-period

Measurements have been made on the half-period of MsTh (Ra^{228}) with the

result of 5.7 ± 0.2 years, the error being an alleged standard error covering all all known sources of error except the perversity of nature.

These measurements originated from discussions with Dr. C. W. Mays, who found a value of 5.1 years to be more consistent with his data than was the accepted value of 6.7 years [Meitner, Phys. Z. 19, 257 (1918)]. Sources were available which gave promise of distinguishing between 5.1 and 6.7 years. In view of the importance of this half-period in estimates of relative Ra and MsTh toxicity to humans, these sources have been analyzed. A more refined determination of the MsTh half-period is, of course, in order.

The ratio of RdTh activity to MsTh activity in an aged MsTh sample is given by the ratio $T_M/(T_M - T_R)$, where T_M is MsTh half-period and T_R is RdTh half-period. Since the RdTh half-period is evidently well established, one can calculate T_M if the relative RdTh/MsTh activities in an aged sample can be measured. (A suitably modified formula handles MsTh samples of any known age.) This method has been used here, and was one of two methods used by Mays.

The available sources were:

(1) Two old medical radium needles containing MsTh now at about 10 percent the activity of the Ra^{226}.

(2) Two pure Ra^{226} standards of rather similar construction and totalling very nearly the same Ra^{226} activity as a single radium needle.

(3) Some aged thorium nitrate having MsTh and RdTh at essentially equal activities.

(4) A RdTh solution.

By scintillation analysis the 3 sets of γ-ray spectra (Ra^{226}, MsTh, RdTh) were separated and the relative MsTh and RdTh activities in the old needles determined. In this process the particularly useful γ rays are: RdTh 2.62 Mev, MsTh 0.90 and 0.96 Mev, hereafter referred to as 0.93 Mev. The counts at 2.62 Mev are almost unique to RdTh, although Ra gives a small contribution. The counts at 0.93 Mev are attributable to Ra and RdTh as well as MsTh. The main problem is to subtract out the Ra and RdTh contribution at 0.93 Mev, leaving the net MsTh counts at 0.93 Mev to be compared with the net RdTh counts at 2.62 Mev. The Ra contribution at each of several prominent Ra peaks has also been sorted out to give information on self-absorption in the radium needles as compared with the Ra^{226} standards and the Th nitrate standards.

Five series of measurements were made, each with greater care than all its predecessors combined. Two of the measurements were unsound, the other 3 yielded, in order of increasing accuracy, half-period values of 5.51, 5.80, 5.65 ± 0.2 years. The most probable value from these measurements is 5.7 ± 0.2 years.

(R. A. Dudley)

C. Dosimetry and Instrumentation Techniques

1. Fast Neutron Dosimeter

The construction and initial testing of a scintillation-type fast neutron dosimeter based on the Bragg-Gray cavity principle has been reported previously[1]. The dosimeter consists of a thin 2" diameter scintillator cavity of evaporated CsI(Tl) sandwiched between lucite disks, one face of which is viewed by a photomultiplier tube. Dose measurements are made with the neutron beam incident perpendicularly to the plane or face of this "sandwich". Because the detection efficiency of the scintillator for heavy charged particles (recoil protons) is unity and because linearity prevails, the dosimeter may become an absolute measuring device if the output pulse height or energy loss to the cavity can be calibrated in terms of Mev. A new series of dosimeters has been constructed and several have been tested for absolute dose measurements using a PuBe neutron source and 2.5-Mev and 14-Mev monoenergetic neutrons obtained from the d-d and d-t reactions at a Cockcroft-Walton accelerator.

a. Calculated first collision dose

The absolute measurements of absorbed dose in the cavity are to be compared with the calculated first collision dose to the surrounding material (plexiglas, taken to be $C_5H_8O_2$). Because the dimensions of the dosimeter are quite small compared to fast neutron mean free paths, multiple collisions may be neglected.

Assuming isotropic elastic scattering in the center-of-mass system, the average energy imparted by a monoenergetic fast neutron to a target nucleus of mass A is

$$E_r = \frac{2AE_n}{(A+1)^2} \tag{1}$$

where E_n is the incident neutron energy. The dose received by a monoatomic material is then simply

$$D = \frac{\Phi N\sigma(E_n)}{\rho} \frac{2AE_n}{(A+1)^2} \frac{\text{Mev}}{\text{g}} \tag{2}$$

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1. AECU-4285, M.I.T. annual progress report, May 1959.

where

Φ = the time integrated neutron flux in neutrons/cm^2

N = the number of atoms (of mass A)/ cm^3

$\sigma(E_n)$ = the total elastic scattering cross section at the neutron energy E_n.

ρ = the density of material (1 rad = 6.25×10^7 Mev/g)

In a polyatomic material one may simply add the dose received by each constituent element

$$D = \frac{\Phi E_n}{\rho} \sum_i n_i \sigma_i(E_n) \frac{2A_i}{(A_i + 1)^2} \qquad (3)$$

where the summation is extended over all elements i and n_i is the number of atoms/cm^3 of each element. If the incident neutron flux is not monoenergetic but rather a distribution or spectrum of energies, then an integration of cross section over the energy range must be carried out, e.g., in the case of the PuBe neutron source spectrum.

A tabulation of dose in rads per unit neutron flux for soft tissue may be found in NBS Handbook 63[2]. The calculated first collision dose was carried out similarly for plexiglas but does not differ significantly.

A note of caution concerning Eq. (1) is in order. It is known that neutron-proton elastic scattering is almost completely isotropic (s-wave only) up to about 14 Mev; however, this is not true for heavier targets, such as C, N, or O. Therefore, Eq. (1) should be rederived, introducing the angular distribution by means of the measured differential scattering cross section. In the calculations for plexiglas, this has been done. However, since the energy absorbed by heavier target nuclei is so small compared with H, very little net effect is realized. The energy absorbed to reactions and resulting activities must also be considered. An accurate and exhaustive first collision dose calculation at 14 Mev for several organic materials has been carried out by Randolph[3]. These results are used for comparison with the measured dose at 14.1 Mev.

b. Energy calibration

The light output per unit energy loss of the evaporated CsI(Tl) screens

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2. N.B.S. Handbook 63, U.S. Dept. of Commerce 1957.
3. M. L. Randolph, Radiation Research 7, 47 (1957).

for both protons and α particles has been measured. This comparison is necessary because one may more conveniently calibrate the output pulse height for a calculable energy loss in the screens with an α source keeping in mind that the dose from neutrons in an organic material is really being delivered by recoil protons. It is known[4] that the light output per unit energy loss in single crystal CsI(Tl) is about a factor of 1.6 larger for protons than for α particles and there is reason to believe that this factor might not be the same for the evaporated screens. Knowing the light output factor, one would measure the pulse height of a calculable energy loss from collimated α particles incident on a bare unsandwiched evaporated CsI(Tl) screen of known weight and would thus also have the proton calibration.

While using 2.5-Mev monoenergetic neutrons at the Brown University Cockcroft-Walton accelerator, a thin 2.94-mg/cm^2 polyethylene proton radiator was used with two bare CsI(Tl) screens. A brass collimator with 5 holes was placed between the radiator and the screen. Therefore, essentially forward-directed proton recoils possessing the full neutron energy were incident on the screen. After the proton measurement on each screen, the neutron beam was turned off and a thin Po^{210} 5.3-Mev α source was inserted in place of the polyethylene for the α measurement.

In contrast with the single crystal CsI(Tl), the light outputs per unit energy loss in the evaporated screens were found to be equal for protons and α particles. The data show equality within a few percent although a fractional standard deviation as large as 10 percent might be attributed to the measurement.

The difference in relative light outputs for protons and α's between single crystal CsI(Tl) and evaporated polycrystalline CsI(Tl) is discussed in Sec. C4 of this report.

c. Dose measurements

The output information of the dosimeter is a differential pulse-height spectrum where the pulse height in volts has been calibrated in terms of electron-volts energy loss in the scintillator cavity. Integration of this pulse-height spectrum, weighted by energy and divided by cavity weight, yields a dose measurement in Mev/g or equivalently in rads.

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4. A. E. Souch and D. R. Sweetman, Rev. Sci. Instr. 29, 794 (1958).

The shape of the observed pulse-height spectra from monoenergetic neutrons agrees with what one would qualitatively expect. At low energy one finds a large peak due to a preponderance of energetic, near-forward-directed recoils passing through the screen almost perpendicularly. Thus, a great many particles lose minimal energy in the cavity. This large low energy peak rises abruptly on the low energy side but decreases gradually at higher energies representing the great variety of slower, more obliquely entering recoils which suffer larger energy losses in the screen. The position of the large low energy peak from forward-directed recoils generally agrees within a few percent with that calculated by the product of specific ionization for somewhat energy-degraded recoils and screen thickness.

In a dosimeter based on the Bragg-Gray principle one measures the dose delivered to a thin cavity, which is generated by recoils from its surroundings. Initially and ideally the cavity should be of the same material as the surroundings, which is usually a "tissue equivalent" organic material. If the cavity and surrounding material are of different atomic character the dose in the surrounding material may be inferred by the following energy-dependent correction:

$$D_{mater.} = \frac{\left[(1/\rho)(dT/dx)E\right]_{mater.} D_{cav}}{\left[(1/\rho)(dT/dx)E\right]_{cav}} \qquad (4)$$

$$\equiv R(E) D_{cav}$$

where ρ and $(dT/dx)E$ are density and specific ionization. This correction $R(E)$ should be applied at each recoil energy; however, the correction may be applied at an average incident recoil energy, $\bar{E}_p$, with little error. The average incident recoil energy is naturally a function of incident proton energy and it thus becomes necessary to know the incident neutron energy spectrum in order to find the material dose from the measured cavity dose.

It is a serious drawback to have to know the incident neutron energy spectrum before being able to determine the material dose. In practice, if the neutron energy spectrum were known one could quite easily perform a dose measurement by measuring only the flux and consulting a calculation of first collision dose in the particular material of interest.

For a cavity material having a relatively high atomic number, e.g., CsI with $\overline{Z}$ = 54, compared with the low Z organic surroundings, this correction is strongly energy-dependent at low energies, decreasing by a factor of 2 between 600 kev and 2.4 Mev. At higher recoil energies the correction is relatively energy-insensitive, however. Bearing this difficulty in mind, the dosimeter was tested using known neutron energies. Since these dose measurements were made, it has been found possible to evaporate several much lower Z alkali halide scintillators which should very much alleviate this problem.

The results of the absolute dose measurements are presented in Table 16. The errors quoted in the values of measured dose are those associated with the correction for specific ionization, $R(\overline{E}_p)$, the energy $\overline{E}_p$ at which it is applied, energy calibration, counting statistics, and cavity weight. A relatively large additional error in the measurement at 14.1 Mev was contributed by the large γ-ray background encountered at this energy. This large background made the estimation of the low energy cut-off of the neutron-produced spectrum quite difficult. The error quoted on the calculated absorbed dose results from counter positioning, (to find the flux φ), cross-section errors, and the errors in standard neutron sources.

It is seen that in all cases the agreement between absolute measured and calculated doses are within experimental error. The uniformly lower measured dose, compared with the calculation, indicates either an unaccounted-for systematic error or a consistently incorrect parameter determination. If one were to abandon the absoluteness of the measurements to consider a proportionality factor between measured and calculated dose, such as 0.8, for example, the agreement would, of course, be much better and consistently so for all measurements.

d. Gamma ray and directional sensitivity

The CsI(Tl) cavity of the dosimeter is sensitive to electrons from γ rays. Due to the thinness of the cavity an individual swift electron loses negligible energy, but the pile-up of many electron pulses can extend to higher energies where recoil pulses are observed. The high energy extent of the electron pile-up spectrum is dependent on γ-ray flux. The interference with the recoil proton spectrum is dependent chiefly on the incident neutron energy which determines the position of the large low-energy peak caused by

Table 16. Summary of neutron dose measurements

dosimeter (No.) (30:2.46 mg/cm^2) (37:1.2 mg/cm^2)	neutron energy (Mev)	source-to-dosimeter distance (cm)	measured absorbed dose (rad)	calculated absorbed dose (rad)	$\frac{\text{measured}}{\text{calculated dose}}$
30	2.5	18.6	$0.81 \pm 0.27 \times 10^{-2}$	$0.97 \pm 0.14 \times 10^{-2}$	0.835
37	2.5	18.6	$0.83 \pm 0.27 \times 10^{-2}$	$0.97 \pm 0.14 \times 10^{-2}$	0.86
37	2.5	13.5	$1.32 \pm 0.44 \times 10^{-2}$	$1.85 \pm 0.26 \times 10^{-2}$	0.71
37	2.5	13.5*	$1.32 \pm 0.44 \times 10^{-2}$	$1.48 \pm 0.21 \times 10^{-2}$	0.89
30	14.1	154.5	$2.06 \pm 0.64 \times 10^{-3}$	$3.26 \pm 1.14 \times 10^{-3}$	0.63
30	PuBe	9.1	$1.28 \pm 0.46 \times 10^{-2}$	$1.93 \pm 0.45 \times 10^{-2}$	0.66
37	PuBe	11.1	$0.57 \pm 0.21 \times 10^{-2}$	$0.73 \pm 0.17 \times 10^{-2}$	0.78

* There is some doubt as to the accuracy of this distance measurement. Therefore, a different distance, which affects the calculated dose, was calculated by comparing total counts at 18.6 cm and this distance, "13.5 cm".

forward-directed recoils. Thus, for lower energy neutrons with slower forward-directed recoils, the low energy peak is at higher energy and large γ-ray contributions may be easily biased out. The measurements with 2.5-Mev neutrons were made in γ-ray fluxes well above tolerance levels and the proton recoil spectrum could be cleanly extracted from the low energy γ-ray background. The PuBe neutron spectrum has an average energy of about 4.2 Mev and somewhat more interference with the recoil proton spectrum by the γ-ray pile-up spectrum was encountered at γ-ray dose levels which were of the order of tolerance levels. An extremely intense γ-ray flux, due possibly to proton contamination of the deuteron beam resulting in the $H^3(p,\gamma)He^4$ reaction, accompanied the 14-Mev neutron beam. This complication as well as the higher energy recoil proton spectrum made identification of the neutron dose at this energy extremely difficult, as the large low energy forward-directed recoil peak was completely obscured. One can state that the γ-ray insensitivity is dependent mainly on the incident neutron energies being measured. At lower neutron energies, extremely good γ-ray insensitivity may be achieved by simply a low energy bias.

The dosimeter has been found to be directional-sensitive mainly insofar as the average recoil proton energy $\bar{E}_p$ varies as the angle from perpendicular incidence is increased. It is this energy at which the correction $R(\bar{E}_p)$ is applied to the measured dose to the cavity. Therefore, the directional sensitivity observed with this dosimeter is really the result of having a non-tissue-equivalent cavity. Bragg-Gray validity of the thin cavity should be very nearly directionally insensitive.

(H. W. Kraner)

2. Tape Recording of Binary-Coded Nuclear Detector Pulses

a. Introduction

In the M.I.T. annual progress report for May 1959, four courses of action were listed under part C, "Future work", as follows:

(1) Completion of the construction so that at least 8-digit binary numbers could be stored and read out.

(2) Modification of layout and component interconnection so that the tape recorder operating modes could be easily accomplished by a logical panel-switch arrangement.

(3) Procurement of power supplies for the tape electronics system.

(4) Purchase of an analog-to-digital converter suitable for the desired applications of the tape storage unit.

As of April 1960, steps 1, 2, and 3 have been successfully completed. In May 1960, a Model 52-2 RIDL analog-to-digital converter was purchased, thus satisfying step 4 of the above proposal. In parts 1-3 the construction of all circuity was carried out with our own laboratory facilities. Step 2 constituted the major portion of the year's work on this project. As of this writing, however, it can be reported that the tape storage unit is functioning as a complete instrument as proposed in the original reports. It remains now to determine several of its operating characteristics and these will constitute the basis of this report.

To report adequately the final design of the instrument itself, (giving such information as circuit diagrams, component layouts, operating-mode switching-circuits and signal waveforms), would constitute a paper too lengthy to include with the annual report of this laboratory. Consequently, it is planned to submit a report on the design, operation, and applications of this instrument at a later date. This report will contain the results of tests performed on the completed instrument.

b. The recorder

To refresh the reader's memory about this device, a brief description will be given at this point before proceeding to a discussion of the results recently obtained. Should more background be necessary, the reader is advised to consult the annual progress reports for 1958 and 1959 or a paper presented last fall at the annual meeting of the IRE Professional Group on Nuclear Science.[1]

The recorder functions basically as a buffer storage unit for the collection of statistical data arriving randomly in time. It has its greatest value where counting rates are low and the services of a multi-channel

1. F. H. Irons, IRE Trans. on Nuclear Sci., NS-7, 43 (1960).

analyzer are available. To store data on the tape, the data (e.g., scintillation detector output pulses) must first be converted to a binary code representative of each possible event. For 256-channel analysis, an 8-digit code is required or conversely, n-digits will yield 2^n-channel analysis. When an event has been properly coded, an end-of-conversion or storage command pulse appears to indicate that the event is coded and can be stored. The code levels together with the storage command pulse constitute the imputs to the tape recorder. Upon the receipt of the store pulse the tape recorder stores, in parallel at the next available position on the tape, a code for the given event. A closed loop of tape, running continuously, is the storage medium. The closed loop has been selected because the data loss is determined essentially by the amount of data stored on the tape and generally because the closed-loop allows the use of shorter tape lengths for a constant speed tape system. Access to unique positions on the tape is accomplished by means of a clock signal prerecorded around the tape on one of its 14 available tracks. As the tape fills up during the experiment it becomes more probable that the incoming data will be stored in positions already occupied. When this happens, the previously stored event is erased and lost since the recorder has no means of "looking-before-storing". This process is referred to as "over-recording" and is allowed to exist since the data loss is random and nonprejudiced in nature. The tape system is capable of storing and reading back data at a packing density of 667 bits/inch/track at speeds of either 30 or 60 ips. This corresponds to 20 or 40 kc operation. In order to analyze the data accumulated on the tape, the tape is read into the core memory of a multichannel analyzer (or similar device) where it can then be printed or penned out. The tape clock signal, basic to the recording process, is used to transfer each event from the tape to the analyzer and is therefore basic to the read process. It has been established that an 8.3-kc clock rate will reliably transfer stored data from the tape to our RCL core memory and this is somewhat slower than that which the tape is capable of doing.

Finally, although the tape is basically a buffer storage, the tapes may be filed for permanent reference so that a given experiment may be repetitively reconstructed for analysis. A relatively short length of tape (100 ft.) will store 400,000 events that can be transferred to the analyzer in 40 seconds for observation of an experiment that may have otherwise taken several hours to accumulate.

c. Results

In order to make quantitative observations of the operating characteristics of the recorder it is essential to know exactly the actual input of the tape system. At this time the ADC unit for the tape recorder itself is not available. Therefore, the tape recorder was run in parallel with the RCL analyzer, using the output levels of its address scaler and its storage command pulse as inputs to the tape system[2]. To determine the relative performance of the tape storage, the experiment would usually be performed with the RCL analyzer in the 0-127 channel accumulate mode. The spectrum thus stored constitutes the actual input to the tape, N_R. The data stored on the tape at the conclusion of the experiment are then read back into the analyzer in the 128-255 channel accumulate mode. The spectrum thus stored constitutes the tape output, N_o. Use of the analyzer display overlap mode will then give a quick visual check as to the relative performance of the tape recorder. To determine the number of counts lost at the tape recorder (N_L) during the experiment, N_R can be complemented in the analyzer and then reading N_o into this, the difference ($N_R - N_o$) is quickly obtained. To get quantitative data, the results can be printed out of the analyzer core memory as usual.

Using the above procedure, a 127-channel analysis of a Na^{22} source was performed with the tape operating at 30 ips and a clock period of 120 μsec. The results are shown in Fig. 2, where they are represented in a semilog plot of counts vs. channel number. Although a smooth curve is normally drawn in, a point-to-point curve is drawn to demonstrate that the tape essentially duplicates the input curve in spite of the rather low statistics (1500 counts in the peak). The difference in the two curves is caused by the over-recording process which is also random. This accounts for the fact that the tape system does not duplicate <u>exactly</u> the input spectrum shape for small statistics. It is observed that this spectrum occupied 10.7 percent of the capacity of the tape and that approximately 2400 counts were lost due to over-recording. The fact that nearly the same proportionate count was thrown away in each channel can be seen quickly by noting that the curves as plotted differ by nearly a constant displacement. This is expected since the ratio of N_o to N_R should everywhere be constant and the difference on the graph is proportional to the logarithm of this ratio.

2. R. W. Schumann and J. P. McMahon, Rev. Sci. Instr., <u>27</u>, 675 (1956).

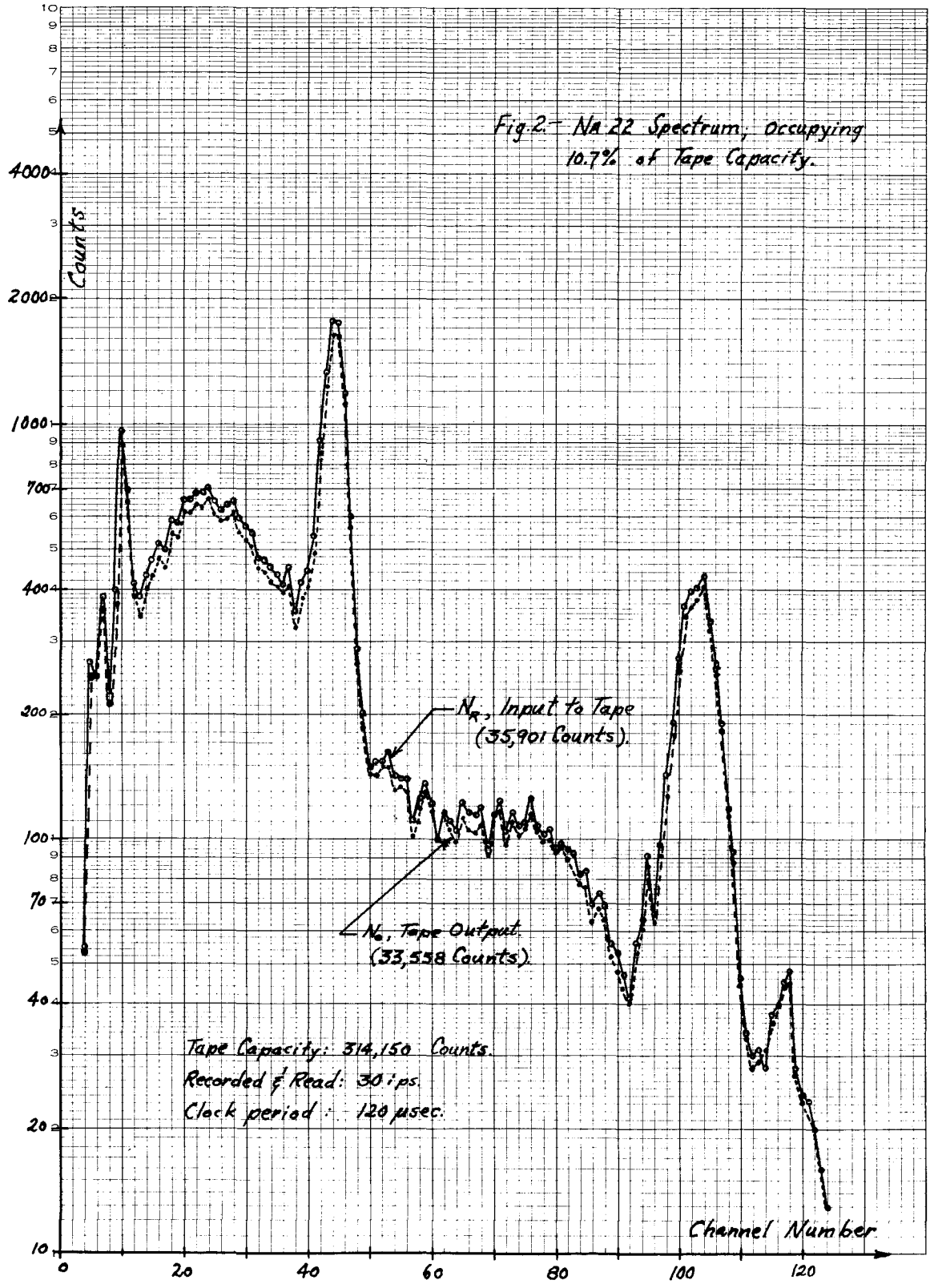

Fig. 2 - NA 22 Spectrum, occupying 10.7% of Tape Capacity.

For the "ideal" loop tape system with randomly arriving inputs having an average rate of appearance, it can be shown that, on the average, the number of counts stored on the tape N_o is related to the number of counts at the input N_R by

$$N_o = M(1 - e^{-N_R/M}) \qquad (1)$$

where M is the total capacity of the tape. A plot of this relationship is shown in Fig. 3. For the data given in Fig. 2 , the value of N_o observed differs by 1.74 percent from the value calculated using Eq. (1) knowing N_R and M. This constitutes remarkable accuracy and would allow one to reliably calculate N_R knowing only the tape capacity and the number of counts stored on the tape.

To establish that the tape reads reliably is easily accomplished by reading the contents of a tape into the analyzer memory, complement the result, and read the tape again. This constitutes subtraction of two successive readings of the tape. A typical result is shown in Fig. 4 for a tape having a capacity of 410,500 counts. The graph shows that the first reading differed from the second by ± 1 count (occasionally ± 2) in 8 random channels. However, the total number of counts N_o was the same for each reading. The given graph cannot be duplicated exactly because the error is random in nature. The error is caused by skew of the tape while reading and also by random dropouts due to tape bounce, impurities, and dust on the tape. The results shown, however, are typical and demonstrate that the readings of data from the tape are reliable to about 10 parts per million, as reported last year when the record system was designed.

In the results depicted by Fig. 2, the data were stored on the tape at a packing density of 277.5 bits/inch/track. Last year it was shown that the tape could reliably handle 667 bits/inch/track (a clock of 50 μsec at 30 ips). However, to reliably read stored data into the analyzer core memory a limitation is currently imposed upon the usable packing density of the tape. The present data indicate this limit to be at 300 bits/inch/track at 30 ips. However, to demonstrate that the tape can be used to record data with a 60 μsec clock signal (277.5 bpi at 60 ips or 555 bpi at 30 ips) the data of Fig. 5 are given. Here, a Mn^{54} source has been used to record a

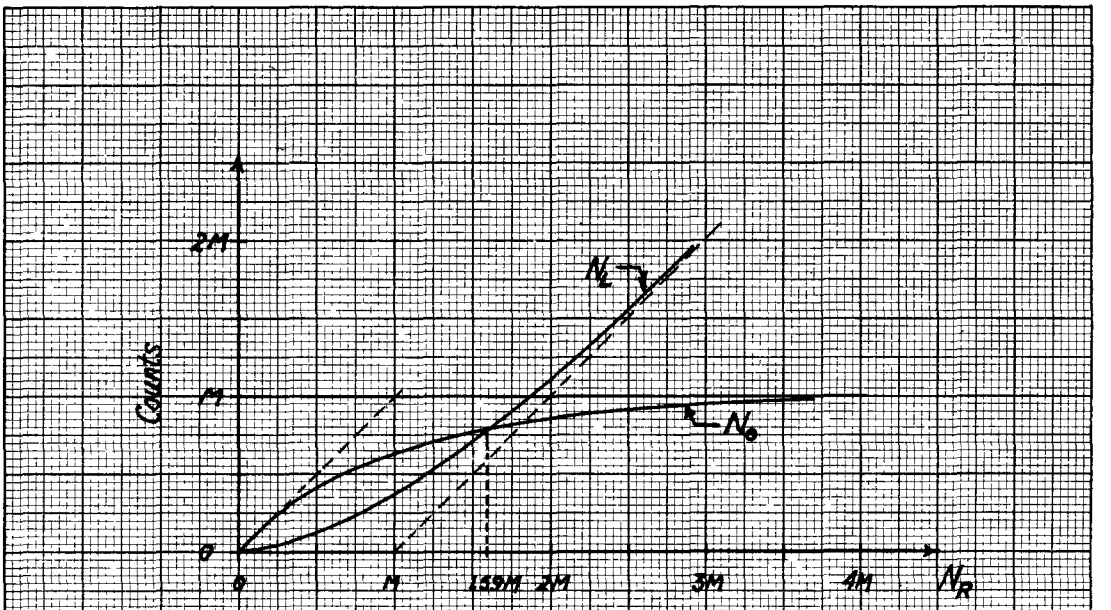

Fig. 3.— Determination of N_R, the total count input to the tape, for purely randomly arriving events knowing N_o, the total number of counts stored on the tape and M, the total capacity of the tape.

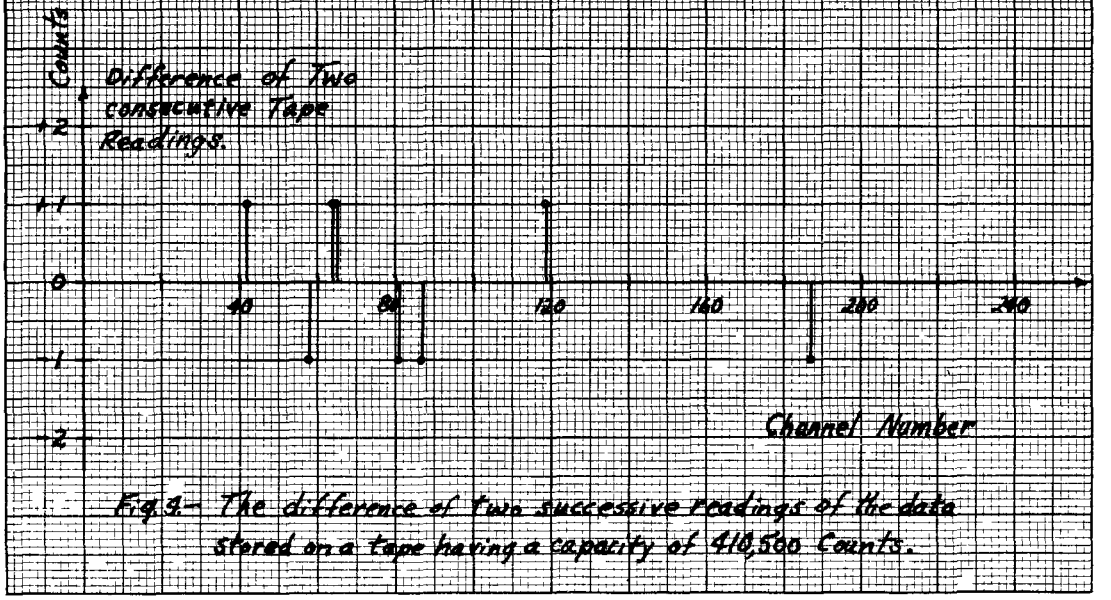

Fig. 4— The difference of two successive readings of the data stored on a tape having a capacity of 410,500 Counts.

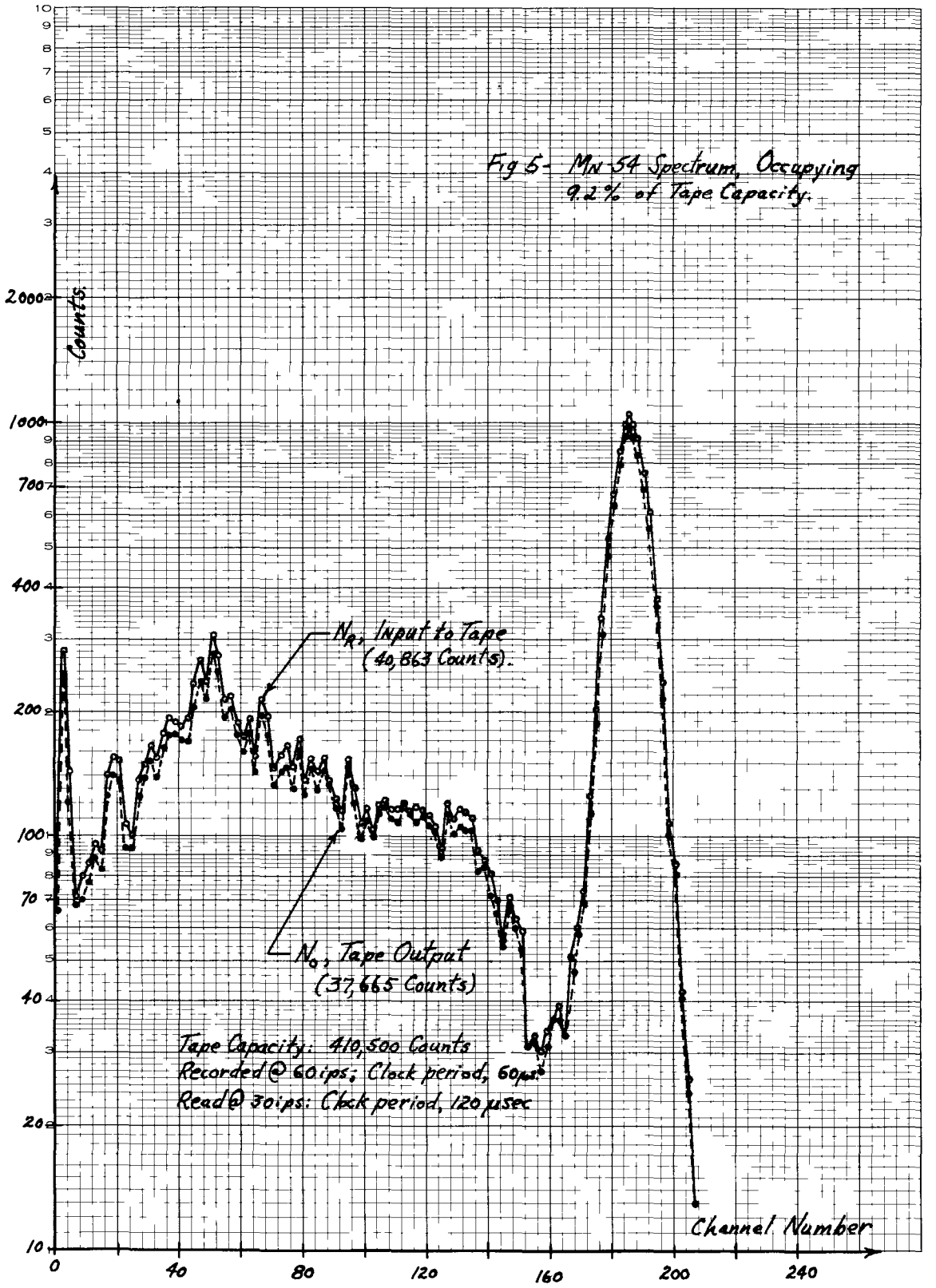

Fig 5- Mn^{54} Spectrum, Occupying 9.2% of Tape Capacity.

0-255 channel spectrum on the tape with a clock of 60 μsec. To reliably read out the data, the tape speed was halved to 30 ips, or a clock of 120 μsec. The results are in good agreement with previous data and show that the shape of the spectrum is maintained in spite of the low statistics and the fact that approximately 3200 counts were lost in the record process. The number of counts on the tape N_o differ by only 3.1 percent from the number predicted by Eq. (1).

To clearly demonstrate the effects of over-recording a large amount of data was recorded on this tape using a Na^{22} source and 0-127 channel analysis. The results are shown in Fig. 6. For this experiment the stored data occupied approximately 51.9 percent of the tape capacity and 43.7 percent of the input data was lost in the record process. The results show that the stored spectrum has retained the shape of the input remarkably well, as would be expected for a good statistical accumulation such as this. However, there is a discrepancy in the results, in that N_o differs by 14 percent from that predicted by Eq. (1). Although it has not been proven quantitatively at this writing, the source of error is believed to be the result of a departure from the ideal in the recording circuitry. To store data at unique positions on the tape requires gating of the store pulse from the ADC and the clock pulse from the tape. Since each of these have a finite duration the stored pulse can coincide with the clock several times during a long-term experiment. When this happens, a pulse hazard exists[3] and nothing is stored. For long-term experiments it has been established that this happens approximately 6 percent of the time for a 120-μsec clock period. This does not account for the excessive data loss in this case, however. At any rate the excessive loss is observed to be random in nature and does not affect the output shape of the desired spectrum. It remains to determine the data losses as a function of filling the tape.

d. Summary and conclusions

Briefly, the following factors have been established:

(1) Storing data in coded form on a magnetic tape loop is reliable and usable to within the statistical accuracy of given ADC units.

(2) The tape system is able to work at higher densities than the

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3. AECU-4285, M.I.T. annual progress report, p. 84, May 1959.

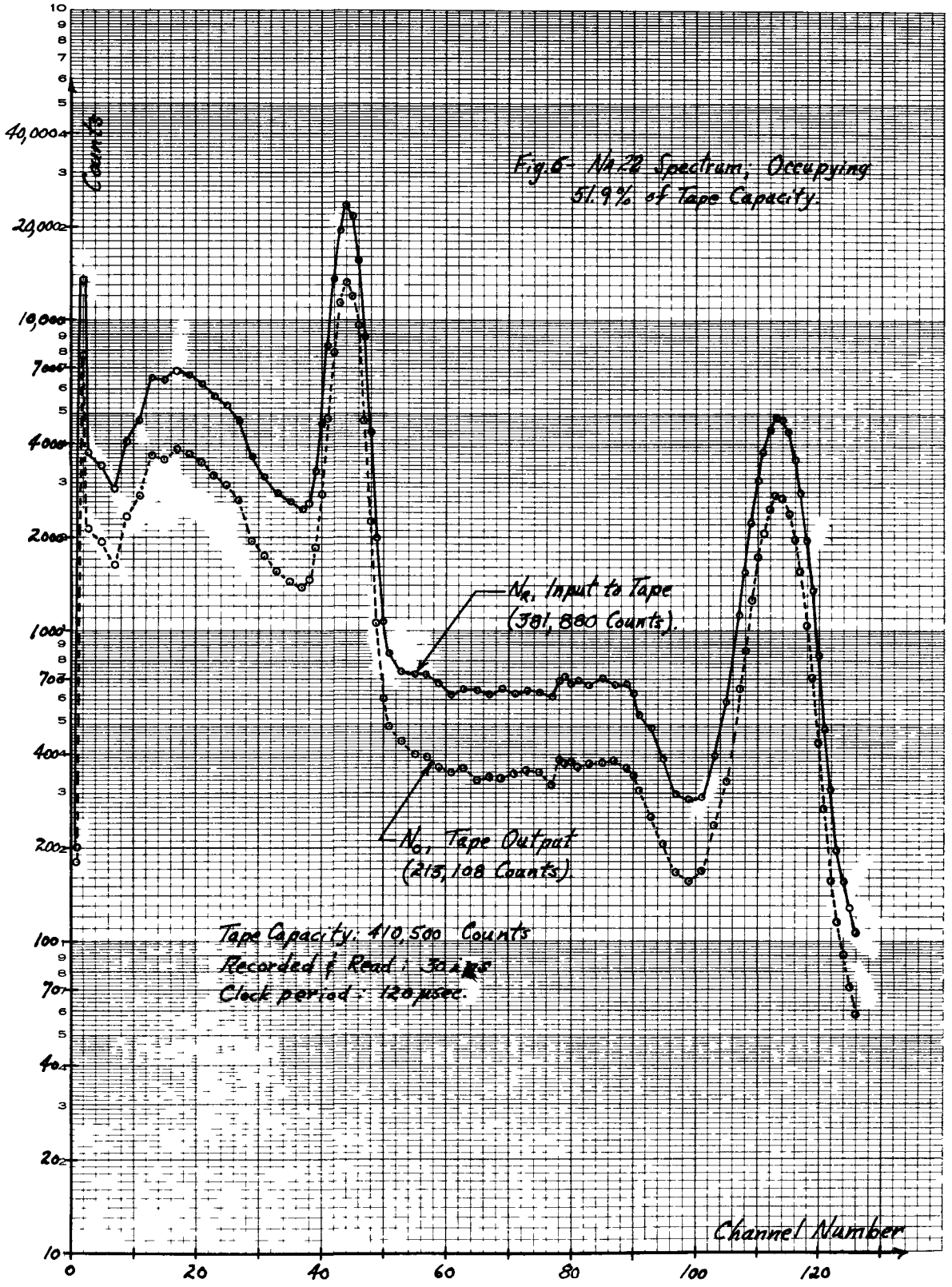

Fig. 6 Mn-22 Spectrum, Occupying 51.9% of Tape Capacity.

available memory unit is presently capable of handling reliably.

(3) The over-recording process, where data are lost while storing data on the tape, does not alter the shape of the desired spectrum. All indications are that it may be possible to calculate the actual input to the tape, knowing only the tape capacity and the data stored on the tape.

(4) The effects of skew and random dropouts incurred while reading the tape are negligible in their effect upon the spectrum. These errors are random and will average out if several readings of the tape are taken. The reliability for the tape system, given by present data, indicates that 10 characters per million are incorrectly read from the tape.

e. Future work

At present the work schedule for this project is as follows:

(1) As soon as the purchased ADC unit for the tape recorder arrives, the tape system will be subjected to continuous operation in the laboratory to determine its performance, dependability, and maintenance problems, if any.

(2) It will be necessary to determine how long a given loop of tape can be used and the number of dropouts expected as a function of tape life.

(3) The feasibility of using the tape recorder to store coincidence information and/or the data from several detectors simultaneously must be established. At present, with the given information it is felt that the data from 3 detectors can easily be stored simultaneously into 4 groups of 0-63-channel analysis, i.e., their sum in 0-63, output of No. 1 in 64-127, output of No. 2 in 128-191, and the output of No. 3 in 192-255.

(4) Finally, it is planned to submit a complete report on this device later this year. This report will contain the design, circuit diagrams, component layout, signal waveforms, applications, and results of typical measurements. In essence, it is hoped that this report will be a complete operation manual for the instrument.

(F. H. Irons)

3. Circuitry Required for Transfer of Data from Tape Recorder to RCL Analyzer

To effect a transfer of data from the tape recorder to the RCL analyzer,

some additional circuits were added to the analyzer. These circuits and their functions are described briefly below.

Normally the memory of the analyzer processes a pulse by adding one count in its memory at an address provided by the address scaler, this process being initiated by the storage command pulse. Therefore, in processing any pulse from the tape, means must be provided to insure that the address scaler will receive the data, and a properly timed storage command pulse must be generated.

Since a synchronized pulse designated as a clock is used in recording data on the tape, it was decided to use it for transferring data to the RCL memory. Using this clock as a timing source, a storage command-reset generator was designed. This generator performs the function of initiating the memory cycle and resetting the address scaler at the appropriate times. Figure 7a shows the time relationship of the data pulse with the storage command and the address scaler rest pulse. Figure 7b is a block diagram of the storage command-reset generator. A control is provided for increasing or decreasing the width of the storage command pulse.

The slow rise and fall time of pulses obtained from the readback heads make them unsuitable as inputs to the address scaler. Therefore, after amplification some pulse shaping is necessary. An NPN trigger which provides a positive pulse is fed into an NPN switch. This switch is the data input for each stage in the address scaler, and is fed into one side of the binary scaler. The circuit is shown in Fig. 8. Upon acceptance of the data, the appropriate grids of the address scaler are "set up". The storage command pulse then initiates a memory cycle and upon completion the address scaler is reset and is ready to begin another similar operation.

Power supplies were incorporated to supply the necessary voltages and are independent of analyzer power supplies.

(J. P. Morris)

4. Evaporated Scintillators

The evaporated CsI(Tl) screens used in the fast neutron dosimeter prompted an investigation of the evaporation of other alkali halide scintillators[1]. Useful scintillating thin screens of NaI(Tl) and KI(Tl) as well as the CsI(Tl) screens have been made by the same very simple technique of vacuum evaporation. CaF_2(Eu) has also been made to scintillate, but with poor light output.

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1. V. E. Hoffman, S.B. thesis, M.I.T., 1960, unpublished.

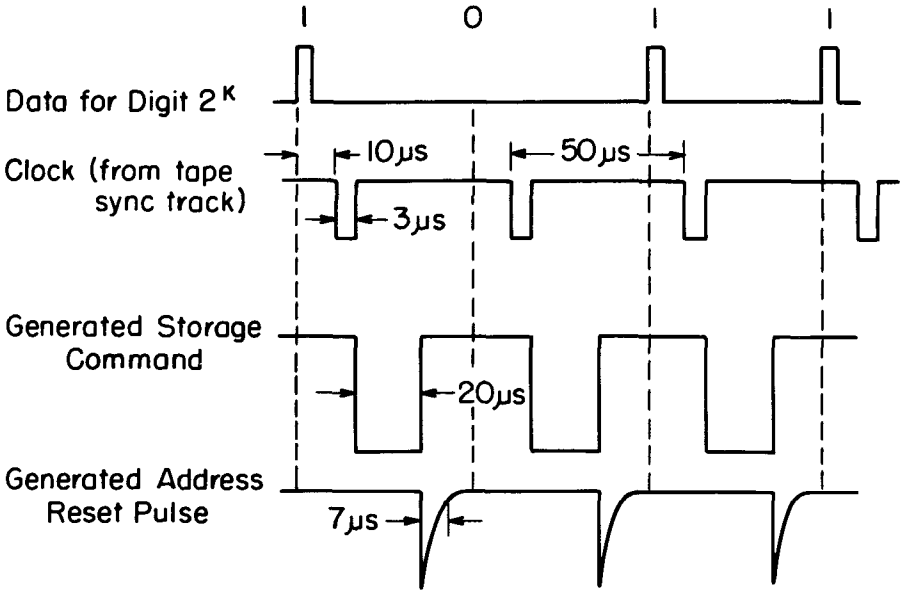

Fig. 7a. - ANALYZE-INPUT WAVEFORMS FROM TAPE

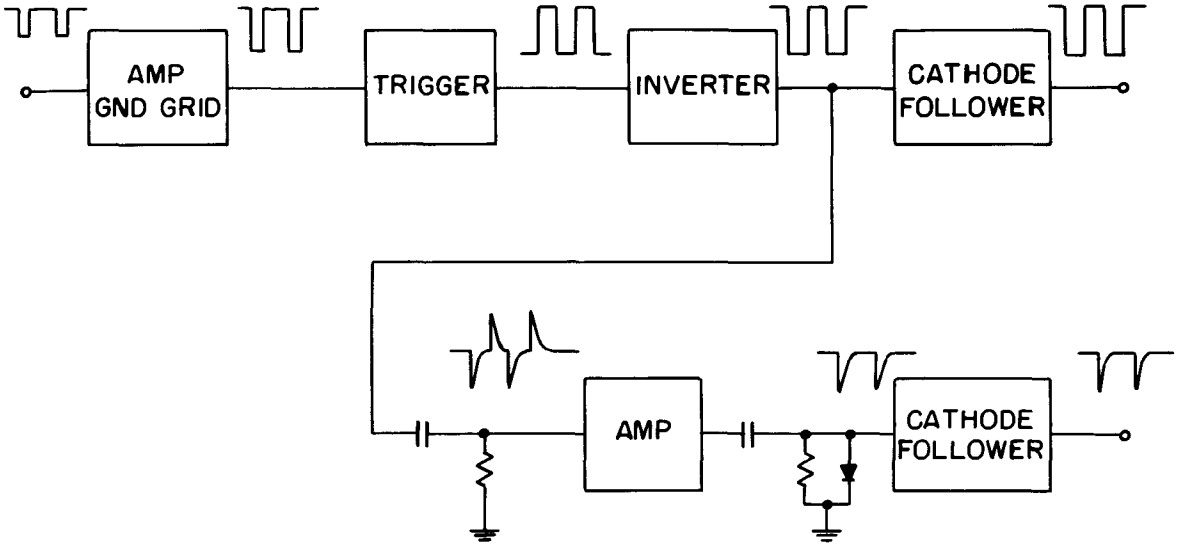

Fig. 7b. - BLOCK DIAGRAM STORAGE COMMAND RESET GENERATOR

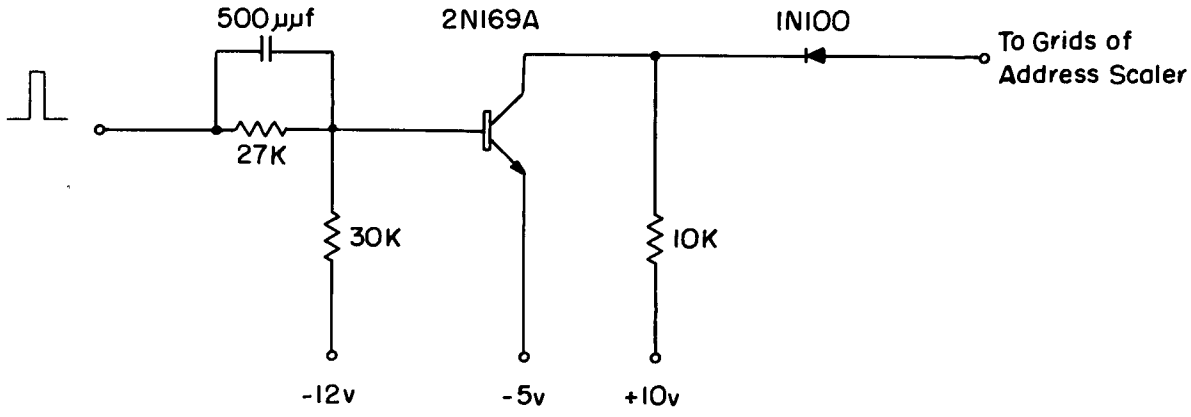

Fig. 8. - ADDRESS SCALER INPUT SWITCH

Considerable effort was given to make evaporated LiI(Eu) and LiF(Eu) scintillate in an effort to achieve a very low Z scintillator. However, no positive results have been obtained. These negative results with LiF(Eu) are consistent with the conclusions of others,[2] who have had no success in growing activated single crystals. The activator in LiI(Eu) was presumably lost in the evaporation.

A sample of single crystal NaCl(Ag), which was supposed to scintillate, was obtained from which several screens and a test single crystal were made. Contrary to the supplier's prediction, neither system was found to scintillate. Some additional Ag doping may be necessary in this compound.

For the evaporated screens and their parent single crystals the light output per unit energy loss has been measured and is compared in the following table.

Relative light outputs of evaporated screens and single crystals per unit absorbed energy from α particles

material	evaporated screen $\frac{\Delta L \text{ light}}{\Delta E \text{ Mev}}$	single crystal $\frac{L \text{ light}}{E \text{ Mev}}$
NaI(Tl)	89	47
KI(Tl)	35.5	14.8
CsI(Tl)	49.5	11.2
$CaF_2(EuCl_2)$	3.6	1.8
LiI(Eu)	-	9

The quantity called "light" is measured in output pulse height and is arbitrary but internally consistent within these data. The energy loss in Mev in the evaporated screens is calculated from the Bethe-Bloch formula taking the α energy to be 5 Mev, which assumes a slight energy degradation from the 5.3-Mev Po^{210} α source used. In the single crystal where the total α energy is absorbed, linearity is assumed so that light/Mev is just the output pulse height divided by the full α energy.

The comparisons of light outputs between screens and single crystal may be somewhat misleading as the light-collecting geometries in each case are

2. R. B. Murray, ORNL personal communication.

different and as much as a 50 percent effect either way could be introduced in this comparison. One should conclude only that the evaporated screens are superior in light output than the corresponding single crystal. The uncertainty in the exact factor of superiority introduced by the different light-collecting geometries should be, however, a constant for the several compounds, as in all cases the single crystals observed were cut to the same size and all the evaporated screens were measured in the same geometry.

Using CsI as a convenient compound, it has also been found that the light output may be slightly improved by adding to the evaporate of CsI(Tl) some additional Tl by means of adding TlI. This result indicates that some Tl activator may be lost in the evaporation when only the Tl in the activated single crystal CsI(Tl) evaporate is relied upon to be carried as the activator in the evaporated screen. This experience in doping led to an attempt at doping pure CsI with external TlI in the evaporate melt. These evaporated screens scintillated with light outputs equal to those from evaporated CsI(Tl). It had also been found that indeed the Tl was necessary as an activator in the evaporated screens as pure CsI screens did not scintillate. Although it has not been tried, it seems probable that pure KI and NaI may also be externally doped with TlI to produce scintillating thin screens. The doping procedures necessary to produce scintillating LiI or LiF screens one could speculate about only after considerably more study and experience with these systems.

It has been found that the light outputs per unit energy loss in the evaporated CsI(Tl) screens are equal when using ~2.3-Mev protons $\left(dE/dx = 53 \frac{kev}{mg\text{-}cm^2}\right)$ and 5-Mev α particles ($dE/dx = 270$ kev/mg/cm^2). This result is in decided contrast to the case of single crystal CsI(Tl) in which

$$\frac{(dL/dE)_p}{(dL/dE)_\alpha} \simeq 1.6$$

for energies such that

$$\frac{(dE/dx)_p}{(dE/dx)_\alpha} \approx \frac{1}{4} - \frac{1}{5}$$

Recently Murray[3] has proposed a simple model of energy transport to luminescent centers in alkali halide scintillators, which assumes energy transport due only to exciton migration. This model reproduces to a fair degree the experimental results of dL/dE vs. dE/dx obtained with particles of various

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3. A. Meyers and R. B. Murray, Bull. Am. Phys. Soc. 5, 37 (1960).

specific ionizations ranging from electrons to fission fragments. By comparing the theoretical and experimental results, a value of 30Å is obtained as the best value for the exciton diffusion length in the single crystal. That the evaporated screens are polycrystalline with domain dimensions much smaller than the screen thickness (~ 20 μ) and perhaps comparable to the exciton diffusion length assumed by this model leads one to conclude that the light output of the screens could indeed be quite different from that of the single crystal scintillator. If the energy released in one microcrystal in the screen is trapped there with no energy transport possible across the crystal boundary, the light output (proportional to number of local luminescent centers activated) should be proportional to dE/dx, or dE, hence giving the effect in dL/dE observed. The relative light outputs for protons and α particles from other successfully activated compounds has not been investigated, which possibility remains for the future.

(V. E. Hoffman and H. W. Kraner)

5. Multiple Crystal Arrays

Some controversy exists between the merits of whole body γ-ray counting with a single large NaI(Tl) crystal versus an array of many smaller crystals.

Clarification of this issue could result from a detailed computation (probably by computer) of the counting efficiency or the figure of merit of a representative crystal array. This calculation could be checked experimentally by the counting of a reasonable phantom by a single crystal (4" x 4") in several positions, thus synthesizing the experimental findings of a multiple crystal array.

The comparison of these results with the experience of single large crystals should, of course, be made from several standpoints related to the proposed use for a particular counting system.

A series of measurements have been completed at several γ-ray energies in the Ra spectrum for a 2-counter array. These experimental studies and associated theoretical analyses are being continued.

(C. D. Geilker)

6. Determination of Thorium Activity Using Coincidence

The possibility of using coincidence measurements to determine small

activities of thorium in the company of its decay products with NaI crystal scintillators has been explored. The method utilizes the γ cascades in the decay of ThC". It is assumed the samples to be measured may contain Ra.

A source is placed between a 4" and an 8" crystal about 1.5" apart. The 4" crystal, together with a single channel analyzer, provides a gating signal when a γ within a prescribed energy range is detected. The coincident spectrum detected by the 8" crystal is recorded by the RCL 256-channel analyzer. Counts recorded in the photopeak of the 2.62-Mev γ serve as a measurement of the Th activity.

Typical data are shown for known activities. The 4" crystal provided gating signals when energies in the range 0.42-0.88 Mev were detected. The observed counting rates correspond to the portion of the 8" crystal spectrum in the energy range 2.52-2.72 Mev.

	coincidence counting rate (cts/hr)	normal counting rate (cts/hr)
0.032 μc Th	12,200 ± 2 percent	66,600 ± 0.9 percent
0.1 μc Ra	60 ± 25 percent	4,150 ± 4.1 percent
background	6.1 ± 11 percent	610 ± 5.3 percent

Based on these data, expected statistical counting errors are shown below for coincidence and normal measurements on samples containing various amounts of Th and Ra. It is assumed that the sample and background are each measured for 1 hour, and that the Ra activity is known. The table does not reflect time necessary to make measurements auxiliary to the two runs mentioned above.

Sample activity	No radium present		Ra activity 50 times Th activity		Ra activity 500 times Th activity	
	coinc. (percent)	normal (percent)	coinc. (percent)	normal (percent)	coinc. (percent)	normal (percent)
5 μμc Th	±197	±337	±197	±338	±207	±352
10 μμc Th	105	170	105	171	114	183
50 μμc Th	29	35	30	36	37	46
100 μμc Th	19	18	19	19	23	28

The advantage of using coincidence is considered insufficient to merit its use. Certain improvements might make this method of measuring Th activities profitable, e.g., replacement of the 4" crystal with another of resolution comparable to that of the 8" crystal, and an anticoincidence shield to decrease the background due to cosmic radiation.

(W. C. Cobb)

7. Response of NaI(Tl) Crystals to γ Radiation

The purpose of this work is to develop the state of the art for the Radioactivity Center at M.I.T. of the identification of γ radiation incident on NaI(Tl) scintillation counters by combining methods of experimental physics with high-speed digital computer techniques. The spectrum which results when NaI(Tl) crystals are irradiated by γ and x-rays is a continuous pulse-height distribution. In this work the more physically meaningful method of representation which is the photon flux incident upon the crystal detector is being investigated.

The present effort is directed toward developing mathematical codes on the IBM-704 Digital Computer at M.I.T. in order to give this more physically meaningful approach both the flexibility and energy discrimination of the present large NaI(Tl) crystal detectors mounted in COBAFAC at the Radioactivity Center. The literature on this aspect of large crystal scintillation detection contains accounts both of laborious hand computation and poor energy discrimination.

Briefly, the method consists of finding a response function which relates the experimentally observed continuous output to the input which is to be determined. When a range of energies is of interest, the set of independent linear equations which results is most easily handled in matrix form. To find an input vector, the inverse of response matrix is multiplied by the output vector corresponding to the experimentally determined pulse height distribution.

A computer code is being developed which, from a few experimental spectra, interpolates intermediate spectra in constructing a response matrix. In principle, the energy intervals in the response matrix can be made as narrow as those in the experimental pulse-height distribution. At present, testing of a 68 x 68 response matrix with energies extending to 840-kev and 12.5-kev intervals is being carried out. For the future development which may necessitate more sophisticated interpolation techniques in order to construct accurate response matrices, the present effort is establishing the guiding principles.

(C. A. Barlow, Jr., B. Chertok, and H. W. Kraner)

D. Miscellaneous Projects

1. Measurement of Neutron-induced Body Radioactivity

Experiments to determine the relationship between the induced radioactivity in an individual and the individual's exposure to neutrons have been started using the controlled background facility (Cobafac) of the Radioactivity Center and the facilities of the M.I.T. Reactor.

These experiments, which are designed to determine the variables and problems, have been carried out with slow neutrons. The general procedure is to anaesthetize the dogs, measure their background radiation in the Cobafac, place the animal on the irradiation facility at the reactor, place gold foils on the animal for flux measurements, irradiate, and remeasure at the Cobafac. Neutron beams have been directed on the ventral, lateral, and dorsal parts of the body. In addition, some experiments have involved irradiation in a "sea" of neutrons. The effect of the fast flux in the slow neutron flux has been determined by shielding the animal with cadmium. Partial body exposures to slow neutrons have been carried out by shielding the anterior or posterior half of the animal with cadmium. Experiments to determine the effects of body weight have been carried out. Experiments to calibrate the Cobafac with Na^{24} injected into the animals are in progress.

Results are still being calculated and are not available at this time.

These experiments have been carried out with a slow neutron exposure equal to 1/5 the maximum permissible weekly exposure or less. When all the variables have been worked out with dogs, it is proposed to continue this study with human beings at these low exposure levels, using both slow and fast neutrons.

(C. J. Maletskos)

2. Measurement of Radioactivity in Soil Samples

Measurements of the radioactivity of preoperational soil samples are being carried out as part of the area-monitoring program of the M.I.T. Reactor. These measurements are being made with the γ-ray spectrometer equipment of the Cobafac of the Radioactivity Center.

Measurements of the effects of sample thickness or weight and of sample density have been made using soils which have been pulverized to 20 mesh.

Dunite and Na_3PO_4 have been used as control soils. Calibrated soils have been made by mixing dunite with known amounts of radium and of thorium. KCl is used as a K^{40} standard.

Measurement of the preoperational soil samples is now under way. Identification of the residual radioactivity in excess of that due to radium, thorium, and K^{40} will be attempted. In addition, the effect of stratification of the activity with depth of soil will be made. No results are available at this time.

(C. J. Maletskos)

3. Radiological Health Survey of Selected M.I.T. Personnel

In cooperation with the Radiological Safety Group of M.I.T. a total body γ measurement was made on all reactor personnel prior to their active participation in the reactor program and prior to the activation of the reactor to full power.

All personnel of the cyclotron and radiochemistry groups were also measured.

In the event of any accident it will be possible to remeasure these people and detect any internal contamination.

Preliminary examinations revealed only two suspect cases, both involving the cyclotron and ingestion of Zn^{65} from repair operations. These were presented in the 1959 annual progress report.

(J. B. Bulkley)

E. Proposed Investigations

1. Th and Ra Uptake from Human Gut

a. Purpose of experiment

An experiment is here proposed on the relative uptake of Th and Ra compounds by humans following oral administration. The purpose of this experiment is to help clarify the skeletal dose estimates for the Ra-MsTh patients now under study in the Radioactivity Center. It is known that many of these patients (a fraction of the dial painters and all of the Radithor cases) were exposed by oral intake to mixtures of unknown proportions of Ra^{226}, MsTh (Ra^{228}), and RdTh (Th^{228}). Ra and MsTh can now be measured with sufficient sensitivity that any burden with a reasonable probability of producing recognizable effects can be quantified. RdTh cannot be measured with sufficient sensitivity, since the long lapse of time (30-40 years) and the short half-period (1.9 years) have permitted excessive decay by now, and since any minute residuum of the initial RdTh intake would be masked by the RdTh descended from the MsTh in the body.

The only hope for clarifying this dosimetry complication is feeding experiments duplicating as nearly as possible the original situation. Certain requirements, among others, are human subjects of appropriate age (e.g., 15-25 years) and Ra and Th salts in appropriate chemical form. There is a reasonable chance that the gut uptake of RdTh may be found to be much less than that of Ra, in which case the RdTh contribution to the skeletal dose can probably be safely neglected. On the other hand, the conclusions drawn from the experiment may be ambiguous: (1) the results themselves may be inconsistent, or (2) it may be demonstrated that RdTh is taken up from the gut comparably with Ra. Either alternative would permit the dose estimates based on Ra and MsTh to be regarded as lower limits only, and would seriously compromise the value of such patients in the over-all study. However, a positive conclusion which could usefully be drawn in case (2) would be that subjects known to have been exposed to MsTh, and hence RdTh, could with justification on dosimetry grounds be excluded from consideration when the Ra and MsTh MPC is being established.

b. Present knowledge on problem

Certain quantitative estimates of the possible importance of RdTh can be made. It is known from human and animal data on Ra, and animal data on

RdTh, that the retention of RdTh once in the blood greatly exceeds that of Ra. Estimates based on these data suggest that 1 μc of RdTh injected into the blood and 25 μc of Ra injected into the blood would result in approximately the same cumulative skeletal dose (averaged over total skeleton) during the subsequent 40 years. The time scale of irradiation is of course rather different, although not so much so as the disparity in physical half-periods suggests since the Ra dose rate is greatly influenced by its excretion pattern. A second important attribute of RdTh is its roughly 10 times greater toxicity than Ra per unit dose, a fact established in the Utah dog experiments and presumably attributable to the differences in localization between Ra and RdTh. The conclusion can be drawn that unless RdTh is taken up from the gut at less than 5 percent to 10 percent of Ra, the dosimetry on many of the dial painters and all of the Radithor cases will have wide limits of uncertainty.

Preliminary experiments on the relative gut uptake of Ra and RdTh in rats and monkeys have been conducted at Utah. The results showed in general a relative RdTh/Ra uptake of a few percent. However, in one case (one of three chemical forms administered to rats) the ratio was reversed, and one presumes that the chemical form of the RdTh and Ra is critical.

The fraction of orally ingested Ra which is retained in the body is known to be low in humans, although the retention pattern over a period of a few days to a month is not clearly established. Low long-term retention is demonstrated by the fact that the total skeletal Ra burden of humans who have ingested Ra continuously throughout their lives is only about 30 times the average quantity ingested per day. Therefore over a period of one or a few years, retention can be at most only a few percent. There have apparently not been any human tracer experiments showing the magnitude of retention a few weeks following oral administration. NBS Handbook 52 cites the gut-blood transfer as 20 percent, based on animal experiments.

c. Dosimetry

The isotopes selected for the proposed experiment should have a half-period of at least several days to permit measurement of retention over a period of time sufficiently long that the gut is entirely cleared. On the other hand, the shorter the half-period the lower the radiation dose. Furthermore, the isotopes chosen should have short-lived daughters to preclude disequilibrium problems, and should emit γ rays.

An examination of all the isotopes of Ra shows a choice between Ra^{224} (ThX, 3.5 d) and Ra^{223} (AcX, 11.7 d). Each series has four α rays. Cumulative doses would be roughly proportional to half-period. The final choice will depend on the sensitivity of detection of the respective γ rays, which can be investigated in the immediate future. Tentatively one might suggest preliminary experiments with ThX to establish the desired activity level, followed by the final experiment with AcX to permit observation over a longer period of time.

An approximate estimate of dose can be made as follows. We know from past experience that ThX in the body can be measured through detection of the ThC" γ rays at a useful accuracy down to about 0.003 μc. The initial amount in the skeleton should be somewhat greater, e.g., 0.02 μc. The dose rate associated with 0.02 μc averaged throughout the skeleton is about 0.006 rad/day, and the cumulative dose assuming no excretion is 0.03 rad. Following a single intake, local "hot spots" might exist with dose rates 10-100 times the average. The best evidence of the toxicity position of this activity is by comparison with Ra^{226}: the industrial maximum permissible concentration in the body, many years after exposure, is 0.1 μc, representing cumulative doses of roughly 200 rads, or several thousand times greater than the average doses here proposed. The industrial MPC implicitly allows for "hot spots" of the order of 10 times greater than the average dose, since this was the situation in the subjects from whom the industrial MPC was derived. It might later be decided to use AcX instead of ThX, but only if the dose situation turns out to be more favorable.

An examination of all the isotopes of Th gives a clear preference to Th^{234} (UX_1, 24 d), the daughter of U^{238}. This isotope decays in two steps by β and γ emission to the long-lived isotope U^{234}, where the decay series effectively ends. The average β energy per Th^{234} disintegration (including the Pa^{234} β rays) is about 0.3 Mev. Conversion electron energy adds to the β-ray energy by an amount which is not well established. In any case, the total beta plus conversion electron energy for the two successive decays does not exceed 2.5 Mev, the sum of the respective Q_β's, and probably is less than 1 Mev. The 1 or 2 Mev of γ energy is not of concern compared with the β energy since its dissipation in the body is not localized. While the retained burdens necessary for measurements remain to be evaluated, the low energy per disintegration gives assurance that the corresponding skeletal doses will be considerably smaller than in the ThX case (about 27 Mev per ThX disintegration).

The intestinal dose should be considered also. For this purpose, it can be assumed very roughly that all the ingested activity passes into the colon, where it resides for one day uniformly mixed throughout a fecal mass of 100 g. If it is assumed that 0.2 μc ThX must be ingested to give a skeletal burden of 0.02 μc, the associated dose to the walls of the colon would be about 1 rad (i.e., one half the dose within the fecal material itself). This is an upper limit, since probably no one part of the colon (and certainly not all of it) would be irradiated for the full day. The Th^{234} dose to the intestines would be little if any greater, even if 50 times as great an activity had to be administered in order to build up the requisite skeletal burden, since its associated disintegration energy is so much lower. These intestinal doses may be compared with the 0.1 rad/yr natural dose, or the 25-100 rads delivered in a single abdominal fluoroscopic examination.

d. Proposed experiment

It is proposed that several subjects, preferably of age 15-25 years, be given tracer doses of ThX or AcX and of Th^{234} in a variety of chemical forms. In a typical case, the isotopes might be fed initially in quantities three times the proposed skeletal burden (0.02 μc in the case of ThX, and values yet to be determined in the case of Th^{234}). If insufficient uptake should occur (as is probable), a second feeding would be planned on the basis of the results from the first. By successive steps the proper activity level could be established with a total dose not exceeding twice that which would result from a single feeding at the correct level.

The chemical forms in which these tracers should be given remain to be chosen. This choice would be the responsibility of chemists, and would be based on duplicating the dial paint or Radithor conditions most closely. Three or four different chemical forms might suffice. Each form might be fed to two persons, for replication purposes. A total group of 8 or 10 subjects would thus be necessary.

The Ra isotope preferred, and the minimum useful skeletal burdens, can be fairly quickly determined by the physicists. The resultant doses would fall approximately at or below the levels quoted above.

2. Dosimetry of Sinus Tumors

One of the surprises in the Ra-MsTh toxicity studies has been the

recognition within recent years of the relatively high proportion of carcinomas of the paranasal sinuses among the malignancies of these cases. Within this group of 181 subjects, for example, there are 25 malignancies of which 9 are sinus carcinomas. The reason for this situation is not known, but must involve either high dose rates or high sensitivity in this region. The dosimetry of the soft tissue in the sinuses is exceedingly complicated for physical reasons: intricate convolutions of the cavities, and variable thickness of tissue overlying the bone. This is a study which, if time and talent can be made available, might yield some important results.

3. The Effects of Irradiation on Bone Collagen: A Correlation of the Gross, Microscopic, Macromolecular, and Molecular Changes

a. Background

It has long been known that irradiation of bone may result in changes visualized both by ordinary microscopy and medical x-ray examination and consists early of localized osteoporosis. In addition, the long-term effect may result in bone sarcoma.

The purpose of this particular study will be to examine the organic matrix of bone which has previously been subjected to irradiation, as well as control specimens, to determine the effects of irradiation on the organic matrix by a variety of techniques (see below). An effort will be made to determine whether ultramicroscopic changes in the structure or aggregation state of the collagen matrix occurs before gross or microscopically visible changes are apparent.

In general, the effects of radiation may be twofold and these must be differentiated:

(1) The effect may be directly on the cell; i.e., the osteoblasts themselves. This may lead to the production of abnormal or pathological collagen macromolecules and other organic constituents which make up the organic matrix of bone, or it may lead to such changes in the collagen macromolecules or other constituents that the state of aggregation of the collagen fibrils is disturbed. Thus, there may be changes in the "dangling ends" of the collagen macromolecules which change the polymerization of the macromolecules[1] or there may be changes in the intermolecular interaction such as that described by Gross and Levene[2] for lathyritic bone.

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1. A. J. Hodge and F. O. Schmitt, Proc. Nat. Acad. Sci. 46, 186 (1960); H. J. H. Highberger, G. G. J. Deffner, and F. O. Schmitt, Proc. Nat. Acad. Sci. 46, 197 (1960).
2. C. R. Levene and J. Gross, J. Exptl. Med. 110, 771 (1959).

(2) The effect may be also directly on already formed matrix. That is, the irradiation may alter the collagen macromolecule or collagen fibril, or both, which has already been formed and is present in the tissue. Such a differentiation of effects has been demonstrated by Gross and Levene in the case of lathyrism.

b. Methods of study

In order to evaluate these effects certain parameters of normal bone collagen must be known from specimens of bone from the same location as that which will be used as irradiated bone specimens. These are:

(1) Amino acid analyses.

(2) Shrinkage temperature characteristics.

(3) Solubility characteristics.

(4) Microscopic appearance.

(5) X-ray microradiography on both the mineralized samples to show the distribution of Ca-P salts, and the demineralized samples to show the distribution and density characteristics of the organic matrix.

(6) A study of the cross-links in collagen, including the possibility of ester cross-links, such as described by Gallop et al,[3] and the epsilon amino cross-link such as that described by Solomon, Mechanic, and Levy,[4] amongst others.

(7) Electron microscopy.

(8) Wide and low-angle x-ray diffraction.

Two types of experiments, therefore, will have to be established. One will be a so-called acute experiment, and the other long-term. Because of the low turn-over of bone collagen, particularly in adult animals, we can study the effects of irradiation on adult dogs. Thus, the changes which we see in the collagen will be changes in the collagen already present prior to irradiation. On the other hand, using rapidly growing animals and possibly animals irradiated during their term in utero, we should be able to ascertain the effects of irradiation on the cells as regards their production of new collagen matrix.

(M. J. Glimcher, M. D.)

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3. P. M. Gallop, S. Siefter, and E. Meilman, Nature 183, 1659 (1959).

4. G. Mechanic and M. Levy, J. Am. Chem. Soc. 81, 1889 (1959).

4. Effect-vs.-dose Relationship in Human Radium and Mesothorium Cases

Ultimately we will be faced with the problem of extrapolating the observations on several hundred humans to predictions applicable to population groups of the order of 100 million people.

Which parameters of the effect-vs.-dose relationship will then be of paramount importance? We should identify these statistical parameters as soon as possible and be sure that the over-all design of the studies on humans maximizes our information on these parameters. For example:

(1) What increase in accuracy can be expected when the size of the observed group is doubled, or quadrupled?

(2) What is the relative importance of cases whose residual radium burden is in the domain 0.001 to 0.01 μg, 0.01 to 0.1 μg, and 0.1 to 1 μg?

(3) Are bone biopsies and microradiographic measurements especially important for the 0.1 to 1.0 μg domain?

(4) Is it sufficient to concentrate our observations on survivors, or are there some especially important data to be obtained by exhuming and studying persons who had a shorter life span?

In the recent literature there have been discussions of models of the effect-vs.-dose relationship for various radiobiological effects (A. M. Brues, H. F. Blum, R. H. Mole, M. P. Finkel, P. R. J. Burch, etc.). Radiobiological data have not sufficed to establish clearly the linear model, or the quadratic, the threshold, the multiple-hit, the log-normal, or any other single model.

There are other scientific fields in which a model for an effect-vs.-insult relationship cannot readily be established. For example, the probability of detonation of munitions which are accidentally dropped while being unloaded from a ship was a pressing and practical effect-vs.-insult problem which arose during World War II. We find that this problem caused the development of sophisticated statistical methods which were used successfully to design small-scale experiments which could be extrapolated to large-scale operations with high confidence, even in the absence of a model of the effect-vs.-insult relationship. The classified reports on this statistical work have just been made available to us by Professor George P. Wadsworth, Dept. of Mathematics, and Professor Harold Freeman, Dept. of Economics and Social Science, at M.I.T.

It is our mutual hope that some extension or modification of this statistical approach can illuminate our problems of design and of extrapolation

of radiobiological observations in which the effect-vs.-insult model is also indefinite. We want to give this new approach a real tryout.

5. Liquid Scintillator Counting of α Radiation from Normal Bone

Foreman and others[1] have shown that the pure α-emitter Pu^{239} can be counted readily in powdered bone samples which are suspended in a liquid scintillator. However, liquid scintillators give about the same pulse height for a 0.5-Mev β ray and a 5-Mev α ray, hence the method has not been extended to measurements of low-level Ra and Th series α rays in bone because natural and artificial β-ray emitters would swamp the desired α pulses.

However, Wright[2] has shown that the pulse shape is different for protons and for Compton electrons in certain organic and liquid scintillators. By electronically sorting the pulses with respect to their decay time, Brooks and others[3] have shown that it is possible to distinguish between proton and electron pulses.

It may be possible to devise detection equipment using a liquid scintillator and suitable pulse height and pulse decay-time sorting circuits which would have a fair chance of giving a satisfactory solution to the old, difficult but important problem of directly measuring the Ra and the Th series activity of human bone samples. Laboratory work has not been started.

6. Optimum NaI(Tl) Shape for Bremsstrahlung Measurements

For the quantitative measurement of bremsstrahlung from Sr^{90}-Y^{90} and other pure β-ray emitters some workers advocate thin crystals of NaI(Tl) (to reduce the background) while others equally strongly advocate thick crystals (to obtain better total absorption spectra). The question can be settled only by a well-designed series of observations in which the response of crystals of several shapes and sizes are compared directly with one another, using bremsstrahlung spectra from several emitters and at several intensity levels.

It is believed that such an experiment is a natural corollary to the experimental and theoretical studies on the physics of bremsstrahlung from continuous β-ray emitters which were completed by J. Lambert Bear in February 1960. The experimental work on optimum crystal sizes and shapes has not yet been started.

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1. W. H. Langham, on p. 142 of "Liquid Scintillation Counting", C. G. Bell, Jr. and F. N. Hayes, eds., Pergamon Press (1958).
2. G. T. Wright, Proc. Phys. Soc. Lon. B49, 358 (1956).
3. F. D. Brooks, pp. 268-269 in "Liquid Scintillation Counting", C. G. Bell, Jr. and F. N. Hayes, eds., Pergamon Press (1958).
   R. B. Owen, IRE Trans. on Nuclear Sci. NS-5, 198-201 (1958).

F. Publications

S. D. Clark, "Where are the cases of radium poisoning?", J. Am. Med. Assoc., 168, 762 (1958).

R. D. Evans, "Compton effect", Handbuch der Physik, 34, 219 (1958).

W. B. Looney, C. J. Maletskos, M. Helmick, J. Reardan, J. Cohen, J. Buchanan, F. I. Visalli, J. Merrill, and W. Guild, "A study of the dynamics of strontium and calcium metabolism and radio-element removal", P/1057 USA, 2nd UN Geneva Conference, 1959.

J. M. Ferguson, "Co^{57} decay scheme", Nuclear Physics 10, 405 (1959).

J. H. Marshall, V. K. White, and J. Cohen, "Microscopic metabolism of calcium in bone", Radiation Research, 10, 197 (1959).

S. D. Clark, "The watches that won't run down. Results of investigations of victims of radium poisoning after an interval of thirty years", Rhode Island Med. J., 42, 239 (1959).

J. Jamison, "M.I.T. studies my bones", The Technology Review, 62, 23 (1959).

R. A. Dudley, "Natural and artificial radiation background of man", in Low-level Irradiation, p. 7, Am. Assoc. Advance. Sci., Washington, D.C., 1959.

F. H. Irons, "Digital storage of statistical data", IRE Trans. Nuclear Sci. NS-7, 43 (1960).

R. D. Evans and N. C. Rasmussen, "Measurement of radioactive isotopes", in Medical Physics,, ed. Otto Glasser, vol. 3, p. 338, The Year Book Publishers, Inc., Chicago, Ill., 1960.

Appendix

Medical Data

All available medical data on persons whose body burden has been determined in this laboratory during the past year are presented here.

A list of the laboratory tests performed, together with their normal limits, are given below.

Hematology:	hemoglobin (hgb)	12-14 g/100 cc
	erythrocytes (rbc)	4.5-5 million/mm^3
	leukocytes (wbc)	4-9000/mm^3
	differential:	P65, L29, M4, F1, B1
	hematocrit (hct)	36-47 percent
	sedimentation rate	0-20 mm (in first hour)
Blood chemistry:	alkaline phosphatase	1-4 units (Bodansky)
	calcium	9.5-11.5 mg percent
	nonprotein nitrogen (NPN)	25-38 mg percent
	phosphorus	2.5-3.5 mg percent
	sugar	80-120 mg percent
	urea nitrogen (BUN)	8-20 mg percent
Electrophoresis:	(g percent)	
	total protein (TP)	6-8
	albumin (alb)	3.5-4.5
	total globulins (TG)	2.5-3.5
	alpha 1 ($\alpha 1$)	0.3-0.5
	alpha 2 ($\alpha 2$)	0.5-0.7
	beta (β)	0.8-1.0
	gamma (γ)	0.8-1.2
Urinalysis:	specific gravity (sp. gr.)	1.005-1.022

Rating system used in x-ray skeletal survey for radiation effects (see Fig. 1, p. 73, for additional details).

changes typical of radium deposition

minimal = 1-8	F = fracture
mild = 9-16	M = miscellaneous
moderate = 17-25	T = tumor
advanced = 25+	

A score of 4+ or 5+ in one area makes the case advanced irrespective of the total score.

(01-002) See case 2 (Miss E. C.), Medicine 31, 221 (1952).
(01-007) See case 7 (Mrs. F. W.), Medicine 31, 221 (1952)
(01-008) Born 14 July 1900. She was employed as a radium dial painter for 6-8 months between 1917 and 1918. During this time she is said to have painted 40 to 50 dials per day, tipping the brush in her mouth.

Beginning about 1928 she had a good deal of dental trouble, developing abscesses and bleeding gums and by 1943 she was edentulous. She was first seen in 1940 by the late Dr. Harrison S. Martland. At this time she had some deafness, which was of brief duration. In 1945 she fell downstairs and sustained a simple fracture of the right femur. X-rays revealed scattered areas of radiation osteitis rather generally distributed throughout the body. By 1950 she had become somewhat hard of hearing.

She was admitted to the hospital on 28 August 1955 for another determination of her residual radioactivity by the radium study group. At that time she complained of three different types of headaches. (1) Between 1945 and 1948 she suffered from bilateral frontal headaches which lasted two to three days and were associated with scatomata, nausea, and vomiting. These occurred prior to her menopause and appeared about once a month. (2) In 1950 she developed symptoms of sinusitis with headaches which were relieved by treatment with irrigation and penicillin. (3) As of 1955 she had a neuralgia-like pain over her left face and left preauricular region. She also complained of pain at the base of her neck on the left, extending to the postauricular region. These pains were relieved by aspirin.

Physical examination in 1955 was essentially negative. Laboratory findings in 1955: hemoglobin 12.6 g per 100 ml, white-cell count 4300 (P68, L16, M4, E3, 9 band form polys), hematocrit 48 percent, platelet count 307,500, reticulocytes 0.5 percent, nonprotein nitrogen 19 mg per 100 ml. Urinalysis was negative. Stool examination for blood was negative. X-ray skeletal survey revealed a healed fracture of the right femur and diffuse mottling throughout the entire skeletal system including the skull and ends of the long bones, pelvis, upper shaft of the right femur.

By 1956 she had more or less continuous headaches and visual blurring. Her blood picture at that time was as follows: red-cell count about 3,000,000, white-cell count 4850 to 6400 with normal differential, hemoglobin 8.9 to 9.8 g per 100 ml, platelets adequate, reticulocytes 0.3-0.4 percent, 2-3 plus hypochromia, 1-2 plus anisocytosis, serum protein 6.45 g, albumin 4.96 g, globulin 1.49 g, urea 18.8 mg per 100 ml, cephalin flocculation negative in 48 hours. Her blood picture did not respond to therapy. On physical examination in 1956 she had a slight left convergent strabismus;

the left disc was hazy and somewhat edematous. Knee and ankle jerks were diminished, biceps reflexes were absent.

By July 1958 she was extremely deaf, blind in one eye, and required opiates around the clock for pain. X-rays taken in July 1958 indicated that there had been a gradual progression of radiation changes in all bones. These changes consisted of areas of osteoporosis with marked condensation of the bone at the upper and lower extremities of the long bones. In the skull there was some generalized increase in density throughout the parietal and frontal regions where the normal bony architecture was more or less obliterated. Some changes were seen in the paranasal sinuses. There was thickening of the lining membrane of the maxillary sinus on the left side and to some degree in the ethmoid cells on the left.

Her condition gradually deteriorated and she died 2 September 1958. Autopsy showed carcinoma originating in epithelium of accessory respiratory sinus.

(01-009) See case 9 (Mrs. F. R.), Medicine 31, 221 (1952).

(01-014) See case 14 (Mrs. H. G.), Medicine 31, 221 (1952).

(01-016) See case 16 (Mrs. K. W.), Medicine 31, 221 (1952) and case (K. Wd.) M.I.T. progress report (AECU-3774) May 1958. As of 1960 patient is reported to be in good health.

(01-017) See case 17 (Miss J. J.), Medicine 31, 221 (1952) and case (J. Ja.) M.I.T. progress report (AECU-3774) May 1958. In the summer of 1958 patient sustained a second pathological fracture of the left femur. By 1960 she had made a reasonably good recovery and was walking with a minimum of difficulty.

(01-023) See case 23 (Mrs. R. W.), Medicine 31, 221 (1952) and case (R. W.) M.I.T. progress report (AECU-3774) May 1958.

(01-027) See case 27 (Mr. J. U.), Medicine 31, 221 (1952) and case 01-027 of M.I.T. progress report (AECU-4285) May 1959.

(01-032) Born 1908. Luminous dial painter for 4 years, 1924-1928, starting at age 16. Developed tumor of left hip and anemia. Died in 1940. Autopsy showed osteogenic sarcoma of left femur, necrosis of mandible, multiple metastases.

(01-038) Born 4 February 1910. Present Health: good, and has been in recent years.
Systems Review: no disturbances of eyes, ears, nose, or throat. No history of any swollen glands in the neck or elsewhere. Cardiorespiratory: normal. GI: negative. GU: has been subject to several attacks of bladder infection, the last one being approximately one year ago. Catamenia: menarche at age 13. Periods regular to the present time. No intermenstrual flow or discharge. Neuromuscular: some pain in right elbow and thumb after exertion.

No other joint disorders. Occasional headaches before periods. Skin: no abnormalities. Habits: appetite good, question of some recent weight loss lately. Sleeps well at night. Does not smoke. Alcohol consumption minimal. Exercise consists of housework. Past History: usual childhood diseases with no specific history of scarlet fever, rheumatic fever, diphtheria, allergy, epilepsy, or mental disorder. Operations: had a vein stripping operation on right leg two years ago, uneventful recovery. No other hospitalizations. No accidents, injuries, fractures, or confining illnesses. Family History: father, 79, living and well. Mother, 69, living and well. Two siblings living and well. One sibling died in mental hospital, question of brain injury. No family history of cancer, diabetes, tuberculosis, epilepsy, or allergy. Marital History: married 30 years to the present time. Husband, 51, living and well. Four children living and well, ages 28, 24, 17, and 7. One miscarriage between 2nd and 3rd child. Older two children each have children of their own, living and well. Dental History: no great trouble with teeth. Has lost only five to the present time. No trouble with healing after extraction. Dental x-rays were taken. Radium Exposure: consisted of painting watch dials from 3 February 1927 to 22 March 1929, starting at age 17. Admits to no mouth pointing, no luminescence remembered.

Physical Examination: well-developed and nourished woman, weight 113 lbs., height 60", BP 160/100, pulse 82 and regular. Eyes: somewhat prominent, but no lid-lag or other signs of toxic goiter. Extraocular movements normal. Pupils react normally to light and accommodation. Ears: negative. Nose and Throat: normal. Neck: no palpable thyroid or glandular enlargement. Heart and Lungs: normal. Breasts: normal female. Abdomen: soft and relaxed. Liver and spleen not felt. Extremities: scar from vein stripping operation. Reflexes: equal and active.

Lab. Findings: Urinalysis: sp. gr. 1.013, albumin neg, sugar neg, few epithelial cells. Hematology: wbc 6800; differential P59, L35, E1, M5, rbc normocytic; sed. rate 25 mm/hr. hematocrit 38 percent. Blood chemistries: BUN 16.3 mg percent, sugar 156 mg percent, alk. phos. 3.2 units. Hinton negative. Electrophoresis (grams percent): TP 6.5, alb 4.5, TG 2.0, $\alpha 1$ 0.26, $\alpha 2$ 0.41, β 0.60, γ 0.77.

X-ray Findings: skeletal survey shows no evidence of radium poisoning. Dental films fail to show any peridontal disease. No definite abnormalities are seen in the alveolar processes.

(01-039) Born 4 November 1913. Present Health: good at the present time. Systems Review. Head: rare headaches. Years ago she would get occasional fainting spells. There have been none in the last several years. Eyes: wears glasses for near vision. Many years ago had some sort of infection of her right eye. Ears: hearing is good. Has had no ear infections. Nose: sense of small good, no epistaxis. Mouth: no soreness in tongue or mucous membranes, no dysphagia. Neck: no goiter, no history of thyroid disturbance. Breasts: no known masses or infections. CR: at the end of the day notes bilateral ankle edema which may be associated with varicose veins. She has moderate shortness of breath on stair-climbing. No known pulmonary infections. No hemoptysis. No chest pain. No history of rheumatic fever, hypertension, or heart murmurs. GI: her appetite is good. She is gaining, rather than losing,weight. Three years ago she had an episode of nausea, vomiting, and vertigo. Does not recall tinnitus. She was admitted to a local hospital where she had gallbladder and GI series which were negative. Her bowels move once a day; she does not use laxatives. She has had no blood in the bowel movements, and does not recall ever having had jaundice. GU: no infections of the kidney or bladder. No dysuria, no nocturia. Menstrual history: her menarche was at age 13. Her last menstrual period was three to four months ago. She has had no hot flashes, no between-period bleeding or discharge. Neurological: she finds that if she sits in one position too long she develops leg cramps. No seizures or epilepsy. Skin disease: see below. Psychological history: denies nervousness, depression, crying spells, nervous breakdowns, etc. Extremities: no rheumatism or arthritis. See below for varicose veins. Habits: no tobacco, occasional alcohol. No medications. Sleeps only three to four hours a night. Past History: had usual childhood diseases. Allergies: no hay fever or asthma. Gets occasional breaking out of the skin of her arms and neck, which has, at various times, been thought to be due to some obscure allergy or to nervousness. Operations: in 1950 she fell and fractured her left ankle. A closed reduction was done on this; the leg was casted, but she still gets occasional pains and swelling. She has had bilateral leg varicose veins injected off and on since 1950. Serious illness: none. Family History: father died at age 71 of surgical shock following a hernia operation. Mother died in her late 60's of a heart condition and diabetes. A sister died in her late 40's of hypertension and uremia. She has two full sisters and one half-sister, all of whom are living and in good health. Dental History: she has had a number of teeth

capped with gold. She sees her dentist every six months. Has no dentures and considers her teeth to be in a good state of repair. Radiation Exposure: from 2 April 1934 to 18 April 1938, and again from 1949 to 1955, she worked handling "dry radium" watch faces and hands. Her job was to put these onto the works. She never painted dials; never noted any glowing of the skin, never ingested paint, and whenever she did handle hands or faces of watches the paint was always dry.

Physical Exam: height 62", weight 174 lbs., BP 144/82, pulse 76. The patient is quite an obese, well-developed, healthy-looking, alert, apprehensive 45-year old woman in no obvious distress. Head: eyes - pupils equal, react to light and accommodation, extraocular movements normal, fundi within normal limits. Ears: drums intact. Hearing acute. Nose: negative. Mouth: throat negative. Many teeth capped with gold. A number of teeth are missing. The remainder are in a good state of repair. Neck: thyroid not palpated, carotids both pulsating. Breasts: no fixed masses or tenderness. Lungs: good breath sounds, no rales. Heart: not enlarged, normal sinus rhythm, good tones, no murmurs. Abdomen: no scars, no organs or masses felt. Has diffuse tenderness to deep palpation in the right lower quadrant without rebound tenderness. Rectal and Pelvic: not done. Extremities: 1+ pitting edema of the lower legs. Good pedal pulses, very numerous superficial varicosities of both legs. No clubbing of fingers or toes. Skin: normal. Neurological: completely within normal limits. Diagnosis 1: exogenous obesity. Diagnosis 2: bilateral varicose veins of the legs.

Lab. Findings: Urinalysis: sp. gr. 1.018, albumin neg., sugar neg.,15-20 epith/HPF, 2-4 wbc/HPF, occ rbc/HPF. Hematology: wbc 9300, differential P63, L35, E2, rbc slight hypochromia, corr sed. rate 31 mm/hr., hematocrit 40 percent. Blood chemistries: alk. phos. 6.2 units, BUN 20 mg percent, sugar 101 mg percent, Hinton negative. Electrophoresis (in grams percent): TP 7.4, alb 4.8, TG 1.6, $\alpha 1$ 0.25, $\alpha 2$ 0.64, β 0.74, γ 0.94.

X-ray Findings: the skeletal survey shows no evidence of radium poisoning. Incidental findings are: irregularities at the distal ends of the left fibular and tibia, probably due to old fractures; calcification of the soft tissues of both shoulders consistent with bursitis. Dental films show filling defects in the upper incisors on both sides, probably represent caries or nonopaque fillings. No abnormalities otherwise seen, no bony abnormalities identified.

(01-041) Born 15 March 1909. Present Health: her present health is

reasonably good, except for some hot flashes. She had an operation for gynecological repairs three years ago and hepatitis two years ago. From these two episodes she seems to have completely recovered.
Systems Review. Eyes: normal except for some burning feelings from time to time. Ears, Nose, and Throat: negative. No history of any swollen glands of the neck or elsewhere. CR: negative. GI: normal. Bowels regular without laxatives. No history of any blood in the stools. GU: negative. Catamenia: menarche at age 14. Periods regular up to the present time. Flow is somewhat less than it used to be. For the past year she has been troubled moderately with hot flashes; for this she takes Premarin tablets and vitamin tablets. NM: subject to what she calls rheumatic or neuritic pains in the back, hands, and other joints. No history of any swelling or redness. Her feet bother her a lot. She is subject to headaches in the occipital region, particularly when she gets up in the morning. No skin abnormalities. Habits: appetite fair only. No weight change in recent years. Sleeps soundly at night. Smokes one package of cigarettes daily. Alcohol consumption averages one to two drinks per week. She gets sufficient exercise doing housework. Past History: usual childhood diseases. No specific history of scarlet fever, diphtheria, or rheumatic fever. She has been subject to what she calls allergy of the nose for many years. No history of any epilepsy or mental disorder. Operations: tonsillectomy at age 12. Three years ago she had an operation for prolapse of the uterus and an amputation of the cervix. No history of any fractures, other operations, or injuries. She was laid up for nearly two months in April 1957 with infectious hepatitis. Family History: father, age 80, living, with Parkinson's disease. Mother, age 82, living, with arthritis, heart disease, and some diabetes. There are nine siblings, all living and well. No family history of cancer, tuberculosis, epilepsy, or mental illness. Mother has diabetes, as noted above. One sister subject to allergy. Marital History: married 29 years to the present time. Husband, age 54, living and well. Two children, age 27 and 23, both living and well. No other pregnancies, by chance. Of the two children, both are married. One couple had one miscarriage; other couple are expecting a child shortly. Dental History: patient first began to have marked difficulty with her teeth at about age 30. During these next 18 years, she gradually lost more and more of her teeth until 2 — 1/2 years ago she had the last ones removed, and has worn full dentures since that time. There has been no trouble with healing of the jaws after dental extraction. Radiation

Exposure: patient states that she painted watch dials in 1927 when she was 18 years old, from 23 May to 25 October only. She states emphatically that they did not put the paint brush in the mouth. She noticed no glowing of the hair or clothing at night.
Physical Examination: well-developed and nourished woman of 50, height 60 inches, weight 122 lbs., blood pressure 118/78, pulse 78 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. No teeth present with full dentures. Small nontender gland in the left submaxillary region. Thyroid not felt. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female. No masses felt. Abdomen: soft and relaxed. Liver and spleen not made out. Pelvic and rectal examination not done. Extremities: normal. Reflexes equal and active.
Lab. Findings: Urinalysis: sp. gr. 1.008, alb neg., sugar neg., 12-16 epith/HPF bacteria. Hematology: wbc 7,400, differential P41, L56, E3, M1, rbc slight hypochromia, corr sed. rate 0 mm/hr., hematocrit 36 percent. Blood chemistries: alk. phos. 2.8, BUN 20 mg percent, sugar 111 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.6, alb. 4.4, TG 2.2, $\alpha 1$ 0.26, $\alpha 2$ 0.38, β 0.60, γ 0.95.
X-ray Findings: skeletal survey and films of the chest show no evidence of radium poisoning. The skeleton is normal except for very minimal degenerative changes consistent with the patient's age and the heart and lungs are normal in appearance.

(01-046) See case (F. Co.) M.I.T. progress report (AECU-3774) May 1958.

(01-048) See case (M. Da.) M.I.T. progress report (AECU-3774) May 1958. As of 1960 patient is living and well.

(01-049) See case (E. Da.) M.I.T. progress report (AECU-3774) May 1958.

(01-050) Born 11 April 1911. Present Health: considers herself to be in good health at the moment, however, five days prior to exam she had a very sore throat. She consulted her doctor for this, and he put her on three red and yellow capsules a day which she has been taking for the past five days. Her only other complaint, which she associates with her change of life, is hot flashes.
Systems Review. Head: frequent headaches which are occipital and frontal

in nature. These are felt by both her and her physician to be due to nerves. She never has these headaches when she feels calm. They are relieved by aspirin. As a child, had infections of her right ear. Denies recent discharge. She wears glasses for close-up work, no blurring of vision. Sense of smell is good. No epistaxis. No sore tongue and no dysphagia. Neck: no known goiter or history of thyroid dysfunction. Breasts: no infections or tumors. CR: denies cough, hemoptysis, or pneumonia. No knowledge of high blood pressure or heart murmurs. No ankle edema, chest pain, or dyspnea on exertion. GI: appetite good, weight constant. Says that if she eats too many fatty foods she will get some nausea and epigastric pain. No history of jaundice. Bowels move two to three times a day. Does not require laxatives, and has never had blood in her stools. GU: no known infections of the kidneys or the bladder. No stress incontinence. No nocturia. Though she denies any symptoms of this, she says her family doctor has advised her to have a corrective operation for a fallen womb. Catamenia: menarche at age 14. No periods since December 1958. Gets hot flashes, and is given an injection every few weeks to relieve the symptoms of her menopause. Skin: negative. Neurological: negative. Extremities: no varicose veins, etc. Habits: no tobacco, no alcohol. Past History: cholecystectomy and appendectomy in 1948. This followed episodes of abdominal pains associated with vomiting. Serious illnesses: erysipelas which involved the face about twenty years ago. For this she received injections and was isolated for a period of time at her home. Allergies: none. Family History: father died at the age of 74 of hardening of the arteries and cerebral vascular accident. Mother died at the age of 68 of a heart attack. A sister died at the age of 47 of cancer of the liver. Two living sisters, ages 46 and 55, are in good health. No known tuberculosis, diabetes, etc., in her family. Marital History: the patient is married and has two children, a girl aged 29, and a boy aged 30, both of whom are living and well. Dental History: she considers that, for her age, she has quite good teeth. She has no dentures, thinks a few should be removed. Her last visit to the dentist was one year ago. Radiation Exposure: worked as a dial painter from 12 October to 19 December 1925. She remembers that she sharpened the point of the brush on her tongue. She recalls that at night she glowed about the lips and blouse. Does not recall glowing of the hair or teeth.

Physical Examination: height 62.5", weight 133 .bs., pulse 80, BP 164/86. The

patient is a bright, alert, chubby but not obese, healthy-looking 48-year-old woman. Head. eyes: pupils equal, react to light and accommodation, extraocular movements normal, no lid-lag, faint corneal arcus, funduscopic shows 2+ A-V nicking. No hemorrhages or exudates. Ears: slightly diminished hearing on the right. Markedly scarred and questionably purulent tympanic membrane. Nose: negative. Mouth: teeth in good repair. Tonsils enlarged and pink, but no exudates seen. Tongue well papillated. Neck: carotids both pulsating. Thyroid not felt to be enlarged. Breasts: well developed, no masses or tenderness. Lymphatics: no enlarged nodes. Chest: lungs: resonant to both bases by percussion, breath sounds good, has a few persistent fine crackling rales on deep inspiration at both bases which are slightly more prominent on the left. Heart: not enlarged to percussion, tones clear, rhythm regular, rate moderate, no murmurs, A2 louder than P2. Abdomen: right upper quadrant scar of old cholecystectomy. No organs, masses, or tenderness. Rectal and Pelvic: deferred. Extremities: good pedal pulsations, no edema. Bones and joints appear normal. Neurological: completely within normal limits. Cranial nerves. DTR's active and equal. Sensations are intact. Impressions: (1) subsiding tonsillitis, (2) mild menopausal symptoms, (3) early arteriosclerosis, generalized.
Lab. Findings: Urinalysis: sp. gr. 1.008, albumin neg., sugar neg., 8-12 epith/HPF, occ rbc/HPF. Hematology: wbc 6700, differential P73, L23, E3, rbc slight hypochromia, corr.sed.rate 19 mm/hr., hematocrit 36 percent. Blood chemistries: alk. phos. 3.4 units, BUN 21 mg percent, sugar 179 mg percent, Hinton neg. Electrophoresis (grams percent): TP 8.1, alb 5.2, TG 2.9, $\alpha 1$ 0.25, $\alpha 2$ 0.58 β 0.76, γ 1.32.
X-ray Findings: skeletal series fails to show any evidence of bone pathology. Incidental findings are 1. large calcified lymph node in the left hilum as evidence of a primary complex, 2. some incompletely aerated left maxillary sinus as probable evidence of chronic sinus disease. The bones about the antrum show no abnormalities, 3. rather large Pacchionian bodies in the parasagittal region on both sides.

(01-052) Born 3 May 1910. She was employed as a watch dial painter for about 3 years starting in 1924 at age 14. She is presumed to have tipped the brush in her mouth for at least part of her employment period. According to her death certificate she died on 6 January 1930 of radium poisoning and a brain abscess. No autopsy was performed.

(01-054) Born about 1908. She worked as a watch dial painter for 3 years 10 months starting in 1924 at age 16. In 1927-8 a diagnosis of radium poisoning was made following an examination by electroscope. She suffered a spontaneous fracture of the right femur in 1933. X-rays taken at that time showed necrotic patches in the cranium, maxilla, and mandible. In 1937 she was admitted to the hospital because of weakness, severe attacks of pain, and inability to move her jaws. Her past history and family history were said to be essentially negative. X-rays showed the following: four areas of diminished density in the skull, the largest being 16 mm in diameter, irregular density of the facial bones; ununited epiphyses, irregular patches of increased density throughout the entire pelvis and vertebrae bones, old united fracture of neck of right femur. Diagnosis: radium poisoning. She died 20 July 1937 six days after admission to the hospital. No autopsy was performed.

(01-055) Born 8 January 1907. Present Health: in good health at the present time except for varying amounts of high blood pressure which she has had for almost 30 years. She has been on different types of medication. Is now on Raudixon which has been beneficial. She says she tends to be somewhat nervous.
Systems Review: no history of any disorders of consequence of the eyes, ears, nose, or throat. No history of any swollen glands. CR: occasional precordial pains, but these are not related to exertion. They have never been severe. No history of any cough. Only slight dyspnea on exertion. Ankles swell in warm weather. GI: she is troubled with considerable heartburn and gas on the stomach, and feels she has to watch her diet rather carefully. No definite nausea or vomiting. Bowels somewhat irregular; no history of any blood in the stools. GU: nocturia once or twice in the night. Catamenia: menarche at age 12, periods regular until age 50. No flow since that time, no discharge. NM: tendency to bursitis in the right shoulder. Variable amounts of headaches, particularly if she is upset nervously. Skin: several moles have developed in recent years. One has been removed and another is scheduled for removal on the right side of the temple. Hands are allergic to several different types of detergents. Habits: appetite good; weight has gone up about 35 lbs. in the past five years. Sleeps poorly at night. Does not smoke. Alcohol consumption minimal. Exercise consists of housework and walking 1.5 miles per day to and from work. Past History: usual childhood diseases. No specific history of

scarlet fever, diphtheria, rheumatic fever. Question of some allergy to particular foods. No epilepsy or mental illness. Operations consist of three caesarian sections. No fractures. Has lump on spine caused by a fall. Family History: father died at 43 of pleurisy. Mother died at 75 of cancer. One brother died at 53, question cause. No other familial history of cancer. No history of any tuberculosis, allergy, epilepsy, or mental illness. Marital History: married 31 years to present time. Husband, 56, living and well. Three children, born in 1929, 1939, and 1941, all by caesarian section as noted above. No miscarriages or other pregnancies. One of the above-mentioned children died at the age of six and a half of pneumonia. Dental History: began to have trouble with her teeth approximately two months after painting dials, commencing at age 18. Began to have teeth extracted when she was about 30 years old. Now has only eight or ten of lower teeth left. No trouble with healing after extraction of teeth. Radiation Exposure: Worked from 19 February 1925 to 31 March 1925, and again from 8 September 1925 to 14 October 1926. She remembers pointing the brush in the mouth; also remembers luminescence of hair and clothing at night.

Physical Examination: well-developed and nourished woman, height 58.5", weight 145 lbs., BP 162/94, pulse 82. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Remaining teeth in only fair condition. Neck: no cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: scars from three previous caesarian sections. Liver and spleen not felt. Pelvic and Rectal: not done. Extremities: normal. Reflexes: equal and active.

Lab. Findings: Urinalysis: sp. gr. 1.016, albumin neg, sugar neg., 3-5 epith/HPF, 0-2 wbc/ HPF, rare rbc. Hematology: wbc 7700, differential P53, L43, E2, M2, rbc normocytic, hematocrit 44.5 percent, sed. rate 28 mm/hr. Blood chemistries: alk. phos. 5.7 units, BUN 16.7 mg percent, sugar 159 mg percent, Hinton neg. Electrophoresis (grams percent): TP 7.2, alb. 4.9, TG 2.34, $\alpha 1$ 0.27, $\alpha 2$ 0.47, β 0.67, γ 0.93.

X-ray Findings: skeletal survey including teeth shows no evidence of radium poisoning. The heart and lungs are normal in appearance, and only minimal degenerative changes are seen in the extremities consistent with the patient's age. Only the lower anterior teeth remain and there is resorption of alveolar bone. This is no more than might be seen in the normal patient.

(01-079) Born 2 March 1901. She worked as a watch dial painter at one plant from 8 November 1920 to 10 March 1924, at a second plant from about 1929 to 1943. She presumably tipped the brush in her mouth during the period 1920 to 1924. In May 1942 she developed an osteogenic sarcoma of the right femur and had a spontaneous fracture of the right femur which comminuted continuously as the tumor mass grew. She died 28 March 1943. No autopsy was performed.

(01-080) Born 19 November 1902. Present Health: good except for a tendency to get excitable, and this is sometimes accompanied with pounding in the ears and head. Occasional palpitation with one flight of stairs. Systems Review. Eyes: normal except for occasional smarting. Ears: left ear drained for a period of several weeks 1 to 2 years ago with accompanying slight deafness at that time. No drainage since that time. No ringing in the ears or dizziness. No trouble with the right ear at any time. Nose and Throat: normal. No history of any swollen glands in the neck or elsewhere. CR: palpitation only, with slight dyspnea as noted above. GI: occasional indigestion with rich foods. Bowels tend to be constipated, tendency to hemorrhoids. GU: occasional urgency and usually nocturia 1 to 2 times per night. Catamenia: menarche at age 12, periods regular but scant until hysterectomy at age 46, 13 years ago. Had an operation for fibroids of the uterus at age 32. NMS: occasional pains of the fingers. Broke her left femur at the age of 51 while digging in the garden. This presumably was a spontaneous fracture without sufficient trauma to normally cause a break. She was in the hospital for 6 months while this was healing. Good result, no disability since discharge from hospital. No skin abnormalities except tendency to rash with penicillin. Habits: appetite good. Weight went down after the fracture but then gradually returned. Sleeps fair, smokes 12 cigarettes daily, occasional indulgence in alcohol, exercise minimal. Past History: usual childhood diseases but no specific history of scarlet fever, diphtheria, rheumatic fever. No other allergies, no epilepsy, or mental disorder. Two operations, one for fibroids, the other for hysterectomy. One fracture as noted above. Family History: father died at 71 of heart disease, mother died at 72 of arteriosclerotic senile dementia. One brother living and well, others died in infancy. No family history of cancer, diabetes, tuberculosis, epilepsy, allergy, or mental disorder. Marital History: married 14 years from 1931 on. After 2 years of widowhood married again, 12 years to the present time. Husband,

There are small punched-out areas of bone resorption less than 10 mm in maximum diameter in both left and right humerus and scapula, score: 1+ each. In the right radius and ulna there are equivocal changes in the form of tiny punched-out areas. Without the changes in other bones, they probably would not be considered significant, score: 1+. There are punched-out areas of bone resorption in the left forearm. The largest is not 1 cm in diameter, score: 1+. Degenerative changes are present in dorsal and lumbar spine, skull base including facial bones, mandible, spine, both feet and ankles, both hands and wrists negative for radiation osteitis.
Conclusion: there are changes as described in the skeleton due to radiation osteitis. The total score is 17F.

(01-081) Born 28 February 1907. Present Health: good at present time and has been in recent years. No significant illnesses.
Systems Review. no abnormalities of eyes, ears, nose, or throat. No history of swollen glands in neck or elsewhere. CR: occasional mild precordial pains not related to exertion. GI: normal. Bowels somewhat constipated. No history of blood in stools. GU: negative. Catamenia: menarche at age 17, periods regular until age 52. Not particularly bothered with hot flashes. NM: occasional mild transient joint pains, never severe. Occasional severe headaches. Skin: normal. Habits: appetite good, no weight change in recent years. Sleeps soundly at night. Does not smoke, alcohol consumption minimal, exercise consists mostly of housework. Past History: usual childhood diseases but no specific history of scarlet fever, diphtheria, rheumatic fever, allergy, epilepsy, or mental illness. Only operation was for hemorrhoids, uneventful recovery. No accidents, injuries, fractures, or other hospitalizations. Family History: father died at 71 of stroke, mother living and well, 78. Five siblings living and well. No family history of cancer, diabetes, tuberculosis, allergy, or mental illness. Marital History: married 33 years to present. Husband, 60, living and well. Two children, 32 and 29, living and well with 6 children of their own. Dental History: has lost probably half of her permanent teeth at present; no trouble with healing after extractions. Radiation Exposure: painted watch dials 5-26 Jan 1923, 12 Feb-9 Apr 1923 at age 15. She remembers putting brush in her mouth, but quit the job because the taste of the paint made her sick to her stomach. She does not remember any luminosity of hair, hands, or clothing.
Physical Examination: a well-developed and nourished, healthy-appearing woman, height 62", weight 136 lbs., BP 134/78, pulse 74 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Teeth in only fair condition for those that remain. Neck: no cervical adenopathy or thyroid enlargement. Heart: normal to auscultation and percussion. Breasts:

normal female, no masses felt. Abdomen: sot and relaxed, liver and spleen not felt. Extremities: mild hypertrophic arthritic change of fingers, moderately severe hallux valgus deformity of feet. Reflexes: equal and active.
Lab. Findings: Urinalysis: sp. gr. 1.016, albumin and sugar neg., 2-4 epith. and 0-2 sbc/HPF. Hematology: wbc 6600, differential P42, L56, M2, rbc normocytic, sed. rate 13 mm/hr, hematocrit 41 percent. Blood chemistries: alk. phos. 2.5 units, BUN 21, sugar 77 mg percent, Hinton neg. Electrophoresis (grams percent): TP 7.1, alb 4.9, TG 2.2, $\alpha 1$ 0.22, $\alpha 2$ 0.34, β 0.70, γ 0.97.
X-ray Findings: degenerative changes in some peripheral joints consistent with patient's age. There is a large osteoma in the left frontal sinus. No evidence of sinus disease seen except for this, probably not related to radium poisoning.

(01-084) Born 15 December 1904. Present Health: her health is good at the present time, and has been in recent years. Recalls no serious illness. Systems Review. Eyes: occasional blurring of vision with reading or watching television. Ears: occasional soreness of the external canals, otherwise negative. No abnormalities of the nose or throat except for a tendency to sinus infection in the wintertime. No history of any swollen glands of the neck or elsewhere. CR: negative. GI: occasional heartburn or substernal distress with a question of its relationship to certain foods such as fried foods. No nausea or vomiting. Bowels tend to be constipated, does not recall any blood in the stools or tarry stools. GU: nocturia 1 to 2 times per night only. Catamenia: menarche at age 15, periods regular until age 50. No evidence of any flow since that time. NM: occasional stiffness in the right shoulder girdle following a triple fracture and dislocation in the region of this joint at age 41. Also suffered an incomplete fracture left humerus at age 42 in an automobile accident. Fracture of one of the metacarpal bones of the left hand at age 50. Some intermittent pains of the left wrist and right ankle for the past few years. No history of any swelling or redness of these or other joints. No headaches. No skin abnormalities. Habits: appetite good. Weight has come down about 10 lbs. with dieting. Sleep tends to be poor. Does not smoke, no alcohol consumed. Gets plenty of exercise at her work. Past History: does not know too much about childhood diseases. Fairly definite that there was no scarlet fever, rheumatic fever, or diphtheria. No allergies, epilepsy, or mental disorder. For accident history see above. No operations or other hospitalizations. Family History: father died in an accident, mother died at 82 of heart disease. Four siblings living and well.

One sister died at age 20 of heart disease. One brother killed in the war. No family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married for the first time from 1936 to 1951 when her husband died at age 49 of bleeding peptic ulcers. Second marriage 1955 to the present. Husband, aged 52, living and well though at the present time has trouble with a back injury. No children and no pregnancies with either marriage. This was not by choice. Dental History: teeth began to get poor while she was dial painting in her early twenties. Gradually by the time she was 36 she had lost all of her teeth. There was no trouble with healing of the sockets after extractions. Radiation Exposure: painted watch dials from 24 September 1923 to 6 October 1924 also from 27 September 1926 to 25 June 1934 and for 5 months in 1935. At first they were instructed to point the brush in their mouth. After, approximately 1926, they were told not to pursue this practice and for the remaining years of her employment she painted dials using a metal pen. She does remember some glowing of the hair and clothing at night after work.

Physical Examination: a well-developed and nourished woman of 55 in no apparent distress, height 60-1/2", BP 146/88, pulse 84 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Wears full upper and lower dentures. Neck: no palpable thyroid or glandular enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal femalr, no masses felt. Liver and spleen not made out. Pelvic and Rectal: not done. Extremities: some limitation of motion of right arm and shoulder joint; extremities otherwise normal. Reflexes: equal and active.

Lab. Findings: Urinalysis: sp. gr. 1.026, albumin neg., sugar neg., 2-4 epith. cells/HPF, rare wbc/HPF. Hematology: wbc 6800, differential P60, L34, E2, M4, rbc normocytic, platelets normal, corr. sed. rate 24 mm/hr. Blood chemistries: alk. phos 3.0 units, BUN 21 mg percent, sugar 77 mg percent, Hinton negative. Electrophoresis (grams percent): TP 8.1, alb 4.25, TG 3.86, $\alpha 1$ 0.46, $\alpha 2$ 0.57, β 0.96, γ 1.87.

X-ray Findings: skeletal survey shows a number of punched-out areas of bone resorption, some of which are over 1 cm in diameter, in the parietal and fromtal bones. Otherwise, the vault is normal, score 2++. There are small punched-out areas in both tibias and fibulas, none of which is over 1 cm in size, score 1+ each. There are small punched-out areas of rarefaction in both humeri, none of which is over 1 cm in diameter, score 1+ each. Minimal punched-out areas of rarefaction in both radii and ulnae, none over 1 cm in diameter, score 1+ each. Left hand and wrist - the

lunate is small in size and shows irregularities in bony architecture which suggest impairment of vascular supply. In view of the radiation changes elsewhere, it is probably fair to ascribe these changes to radiation osteitis. Conceivably, it could be on the basis of injury - score 1+. Degenerative changes consistent with patient's age are present in cervical spine, rib cage including sternum and clavicles, dorsal spine. Skull base including facial bones, mandible, lumbar spine, pelvis, both femurs, both feet and ankles, right hand and wrist - negative for radiation osteitis. Conclusion: there are substantial changes in the skull and minimal changes in the humeri, radii, ulnae, tibiae, and fibulae. The total score is 9.

(01-086) Born 26 September 1907. Present Health: she has enjoyed good health except for two episodes of epistaxis within the past two years. The first episode occurred in the summer of 1958 and she was hospitalized for five days. The second episode was four weeks ago. At that time she was hospitalized for four days. She says her nose was packed to stop the bleeding and that she was worked up for hypertension but that no cause for this bleeding was found. Otherwise, she leads an active life and considers herself to be in good health.
Systems Review. Head: only rare headaches, wears glasses for reading purposes, denies vertigo and tinnitus. No ear infections. Sense of smell good. No soreness of mouth and tongue, and no dysphagia. Neck: no known goiter, no symptoms of altered thyroid function. Breasts: no lumps or infections. Lungs: no known pneumonia, no cough or hemoptysis. CV: denies dyspnea on exertion, and chest pain. Sleeps flat. Notices some ankle edema at the end of a hot day. Has never been told she had heart murmurs or elevated blood pressure. GI: appetite good. No known jaundice. Occasional gas, bowel movements once a day normal in consistency and no melena. GU: for the past couple of months has noted urinary frequency during the day. No dysuria, no nocturia, no stress incontinence. Catamenia: menarche at age 14, menopause at age 49. Has had no bleeding, discharge, or pruritus. NM: no epilepsy, fainting, paresthesias, etc. Skin: no hair changes, gets occasional cold sores about the lips. Extremities: denies varicose veins and claudication. Past History: operations - none. Serious illnesses: none. She had the usual childhood diseases but denies rheumatic fever, polio, diabetes, etc. Allergies: none. Habits: no tobacco. Admits to taking "a couple of drinks" when she becomes depressed. Medications: none. Family History: father died in his 50's, she believes

of cancer of the stomach. Mother died at age 74 of high blood pressure and a cerebral vascular accident. One sister was born dead; a brother died at age 6 months, apparently of spina bifida with a meningocele. Five brothers and one sister are living and in good health. Marital History: is married; she has four children, ages 17, 18, 19, and 29. They are all girls and they are all in good health. Dental History: she does not wear dentures and has not seen a dentist in 15 years. Her teeth give her no trouble, but she admits that they are in pretty bad condition and keep chipping away. Radiation Exposure: was a dial painter from 28 October 1925 to 23 November 1925. She recalls that they were instructed to hold the brush so that their fingers were no closer than 2" away from the tip. She is quite definite that she never touched the brush to her tongue. She thinks that the material tended to spatter. She recalls looking in the mirror at herself while in the dark, and noticed that her hair and blouse glowed in the dark.

Physical Examination: height 59", weight 131 lbs., pulse 80, BP 170/105. The patient is a short, stout, sun-tanned, active-looking, 51-year-old woman who appears to be in good health. Head: Eyes - pupils equal, react to light and accommodation, extraocular movements normal, funduscopic negative. Ears: good hearing, old scars present bilaterally. Nose: no bleeding at present. Has a slight deviation of her septum to the left. Mouth: tongue well papillated. Throat: negative. Teeth in a very poor state of repair with numerous teeth missing and numerous other snags. Neck: carotids palpable, small thyroid. Breasts: no masses or tenderness. Good breath sounds, no rales. Heart: not enlarged to percussion, no thrills, sounds well heard, no murmurs, no venous distention. Abdomen: no scars, no organs, masses, or tenderness. Rectal and Pelvic: deferred. Extremities: no clubbing of fingers or toes, good radial and pedal pulses, poor foot hygiene; 1+ pitting edema of the lower legs. Skin: superficial abrasions of the right forehead and over both tibia, said to be due to a fall. Neurological: completely within normal limits. Cranial nerves all intact. Deep tendon reflexes active and equal. Plantar flexion of the great toes. Impressions: (1) hypertension of unknown etiology; (2) extensive dental caries; (3) recent epistaxis of unknown etiology.

Lab. Findings: not done.

X-ray Findings: the bones of both hands show slight osteoporosis. Films of the ankle show evidence of an old healed fracture of the lower third of

the tibia incompletely included in the picture. There is also evidence of old fracture of the medial malleolus and the distal end of the fibula. The right maxillary antrum shows the mucosal thickening as evidence of sinusitis. There is peridental absorption about the last remaining right lower molar tooth.

(01-087) Born 11 March 1905. Watch dial painter and radium dial lacquerer for 7-1/2 years between 1921 and 1928, starting at age 14. In 1928-9 she was examined by Dr. F. B. Flinn and Dr. S. M. Seidlin who reported that by electroscope she had a body burden of 87 μg of radioactive substance. She has one child, born in 1932 by caesarian section. In the last few years she has developed bilateral cataracts, osteomyelitis of the mandible, and ankylosis of the hips. She has had numerous fractures of the ribs and both femurs. X-rays taken in 1953 showed the medullary cavity to be radiolucent, with alternating sclerotic and radiolucent areas in the head of the femure, acetabulum, and left pubic arch. In October 1957 she was admitted to the hospital for removal of a polyp in the left ear canal. Pathological report showed the growth to be a squamous cell carcinoma. As of 1960 she is in very poor condition.

(01-091) Born 2 October 1909. Present Health: in good health and has not seen a doctor in some time.
Systems Review. Head: in recent years will get mild headaches localized in the vertex which respond readily to aspirin. No fainting spells. Ears: hearing good, no discharge. Eyes: does not wear glasses. No blackout spells. Sees better close up than at a distance. Nose: sense of smell good, no epistaxis. Mouth: no soreness or dysphagia. Neck: no known goiter; if anything, prefers cooler weather. Breasts: no known tumors or infections. CR: no cough, no pneumonia, no hemoptysis, denies chest pain and ankle edema. She sleeps flat, and has never known of rheumatic fever, high blood pressure, or heart murmurs. GI: her appetite is good, weight remains constant. Has no food dyscrasias, no gas, no indigestion, etc. No jaundice. Bowels move once a day, takes no laxatives, and has occasional pruritis ani. GU: no known infections of the kidneys or the bladder, no nocturia, dysuria. Catamenia: menarche at the age of 15, has has no periods since 1941, when she had a hysterectomy. Has had no bleeding or discharge, but does have some dyspareunia which has been checked by her own doctor. Extremities: for the past year has had some

soreness associated with position at the end of her spine, and thinks she has a little arthritis in her right small finger. Neurological: no epilepsy, fits, weakness, paresthesias, etc. Psychological: no nervous breakdowns, no depression. Habits: no tobacco, rare alcohol. No medications. Sleeps about seven hours per night. Past History: operations - in 1940 tonsillectomy which was done for frequent sore throats. In 1941 uterus removed because of a fibroid tumor. Serious illnesses: none; just the usual childhood diseases. Allergies: no hay fever or asthma. In 1958 had several episodes of urticaria following bee stings. Also in the spring of 1958 and 1959, she broke out with pruritic spots mainly on her arms and legs which she thinks are probably due to fleas transferred to her from her pet dog. Family History: father is living, age 82, appears in good health. Mother died at the age of 67; she was a diabetic of many years' duration. Three siblings died in infancy. Nine siblings are living and well, one of whom, a sister, has diabetes. Marital History: she is married, has no children. Has never had a miscarriage, and feels that the fibroid on her uterus was responsible for this. Dental History: has a partial upper plate. Last saw her dentist a little over one year ago, and considers her teeth to be in good shape. Radium Exposure: she worked as an inspector for a period of about five years, 31 January 1927 - 2 June 1931 (intermitt.); 5 September 1933 - 8 December 1933. She feels she started in her late teens. She says that when she began working there the danger was well known, so she had very little exposure. She did not paint dials; she just inspected them, but she says that at times she would get particles of the paint on her fingers. She never recalls having glowed in the dark. In those days, a dance called the Charleston was popular, and at one time she painted her dancing shoes with this luminous paint; she handled these fairly frequently.

Physical Examination: weight 140.5 lbs., height 60-1/4", BP 120/74, pulse 84. The patient is a small, stocky, well-developed, healthy-looking, 49-year-old woman who is in no distress. Head: eyes - pupils equal, react to light and accommodation, extraocular movements normal, fundi within normal limits. Ears: drums intact, hearing adequate, Nose: no abnormality. Mouth: partial upper denture, several teeth removed, the remainder in fair repair. Neck: has a slightly enlarged and palpable right lobe of the thyroid. Breasts: no masses or tenderness. Lungs: good breath sounds, no rales. Heart: not enlarged; PMI in mid-clavicular line. Tones good, no murmurs. Abdomen: has an old, well-healed midline scar between her

pubis and her navel. No organs, masses, or tenderness. Good femoral pulses. Rectal and Pelvic: deferred, but noted that patient does have tenderness to pressure over the end of her coccyx. Extremities: good pedal pulsations, no edema. Skin: she has a number of small,brown,pigmented areas about 5-8 mm in diameter over her skin which are primarily on the extremities, a few being over the trunk. Neurological: within normal limits. Diagnosis: essentially normal, healthy woman.
Lab. Findings: Urinalysis: sp. gr. 1.025, albumin neg, sugar neg., Ca crystals; 2-4 epith/HPF, 1-3 wbc/HPF, 1-2 rbc/HPF. Hematology: wbc 5300 differential P54, L45, E1, rbc slight hypochromia, corr. sed. rate 33 mm/hr., hematocrit 40 percent. Blood chemistries: alk. phos. 7.8 units, BUN 22.2 mg percent, sugar 120 mg percent, Hinton neg. Electrophoresis (grams percent): TP 6.6, alb 4.4, TG 2.2, $\alpha 1$ 0.24, $\alpha 2$ 0.50, β 0.68, γ 0.80.
X-ray Findings: the skeletal survey fails to show any evidence of pathology. A marked reduction in the air content of the left maxillary antrum is seen. There is no evidence of bone destruction and the changes are most likely due to chronic sinusitis. The remaining teeth show no evidence of paradental disease.

(01-093) Born 3 July 1904. Present Health: her health is good at the present time and has been in recent years.
Systems Review: no disorders of the eyes, ears, nose, or throat. No history of any swollen glands in the neck or elsewhere. CR: negative except for occasional ankle edema in warm weather. GI: no great indigestion, nausea, or vomiting. Has been subject to bouts of diarrhea. Had a barium enema one year ago which was reported as being entirely negative. No history of any blood in the stools. Had been troubled with some sort of rectal discharge which alternately healed and then returned. GU: negative. Catamenia: menarche at age 17, periods regular until age 44, some cramps in the legs at night, otherwise negative. Skin: no abnormalities. Habits: appetite good, weight has increased in recent years. Sleeps soundly at night. Does not smoke, no alcohol consumed. Exercise consists mostly of housework and gardening. Past History: usual childhood diseases including smallpox. No history of scarlet fever, diphtheria, or rheumatic fever. No allergies, epilepsy, or mental illness. Operations: had an operation on the ovaries in 1945 in an attempt to promote fertility. No history of any fractures, accidents, injuries, or confining illnesses. Family History: father died at 38 of typhoid fever; mother, 79, living with a certain amount

of arteriosclerosis. Seven siblings. One died at 36 of a postoperative condition; one died at 48 of cancer. Others living and well. No other family history of cancer. No family history of diabetes, tuberculosis, allergy, epilepsy, or mental illness. Marital History: married 31 years to the present time. Husband, aged 53, living and well. One child, aged 13, living and well. No other pregnancies except for a miscarriage at three months at age 25 and another miscarriage at five months at age 29. Dental History: has always had trouble with her teeth, and had complete upper dentures at age 17. The last of the lower teeth were not finally removed until one year ago when she had six extracted. No trouble with healing of the gums after extraction. Radiation Exposure: this patient painted clock dials from 26 February 1926 to 22 April 1926 at the age of 21. Denies pointing the brush in the mouth. Does not remember any glowing of the hair or clothing at night.

Physical Examination: well-developed and nourished woman, height 65", weight 185 lbs., BP 130/82, pulse 68 and regular. Eyes: show slight irregularity of the pupils, but they react normally to light and accommodation. Ears, Nose, and Throat: normal. No teeth at present, wears full upper and lower dentures. Neck: no cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female. Abdomen: soft and relaxed. Well-healed lower abdominal scar. Pelvic and Rectal: not done, but history strongly suggestive of fistula-in-ano which should be explored later. Extremities: normal. Reflexes: equal and active.

Lab. Findings: Urinalysis: sp. gr. 1.023, albumin neg., sugar neg., 2-4 epithelial cell/HPF, 0-2 wbc/HPF. Hematology: wbc 8700, differential P71, L26, M3, rbc normocytic, sed. rate 12mm/hr., hematocrit 42 percent. Blood chemistries: alk. phos. 5.7 units., BUN 19.3 mg percent, sugar 100 mg percent, Hinton neg. Electrophoresis (grams percent): TP 7.4, alb. 5.0, TG 2.44, $\alpha 1$ 0.30, $\alpha 2$ 0.47, β 0.83, γ 0.84.

X-ray Findings: films of the skeleton and of the chest show minimal degenerative changes about both first metatarsal phalangeal joints. There is a cyst-like rarefaction in the shaft of the left femur which has no relation to radium poisoning. It has a sclerotic margin and the bone surrounding it is normal in appearance. Some sort of cyst is the most likely explanation for this shadow. Otherwise, the skeleton is normal in appearance. The heart and lungs show no abnormality. The patient is edentulous.

(01-095) Born 17 July 1907. Present Health: good except for a tendency to obesity and general tiredness for the past 3 years.
Systems Review: no abnormalities of the eyes, ears, nose or throat. Neck: gives a history of occasional episodes of swollen glands. CR: occasional transient ankle edema in the summertime. Has noticed occasional bouts of palpitation of the heart; otherwise, no difficulties. GI: is troubled with what she calls a lot of gas and one gathers there is a certain amount of indigestion. Bowels are fairly regular, no history of any blood in the stools. GU: normal except for occasional nocturia. Catamenia: menarche at age 14, periods regular until age 50 and no flow since; moderately severe hot flashes during the past 2 years. NM: occasional transient pains in the right knee. She is subject to frequent severe headaches coming on approximately once a week; no cause for headaches has been found. No skin abnormalities. Habits: appetite good. With close attention to diet she has lost nearly 40 lbs. during the past few years; her greatest weight was 176 lbs. She is troubled with some insomnia; tobacco consumption 1 package daily, alcohol consumption nil. Past History: usual childhood diseases including scarlet fever. No history of rheumatic fever, allergy, epilepsy, diphtheria, or mental illness. Operated on for fistula-in-ano approximately 10 times until finally another doctor was able to effect a permanent cure 12 years ago; no trouble along these lines since that time. No fractures, accidents, or injuries. Her only child was born by Caesarian section 19 years ago. Family History: father died at 52 of heart disease; mother is 74, living and well. Two siblings are living and well. No family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental illness. Marital History: married 25 years ago to the present time; husband is 49, living and well. One boy, age 19, born by Caesarian section noted above is living and well. No other pregnancies, reason not determined. Dental History: started losing her teeth at the age of 20, and by the age of 38 all teeth were removed. Radiation Exposure: when she was 15 years old she painted watch dials for a period covering one day, 11 July 1922, and then again from 29 January 1923 to 19 March 1923. She remembers definitely that they pointed the brush in the mouth at that time. She remembers that her clothes, hair, and mouth glowed at night when she returned home. No radium exposure since that time.
Physical Examination: well-developed and somewhat overweight woman of 52; weight 150 lbs., height 62-1/2", BP 118/72, pulse 82 and regular. Eyes:

pupils and extraocular movements normal. Ears: normal. Nose and Throat: negative. Teeth all removed, wears full upper and lower dentures. Neck: no cervical adenopathy at this time. Thyroid not palpable. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: soft and relaxed, liver and spleen not felt. Well-healed lower midline scar from Caesarian section. Pelvic and rectal examinations were not done. Extremities: bilateral hallux valgus deformity. Reflexes: equal and active.
Lab. Findings: Urinalysis: sp. gr. 1.008, albumin neg., sugar neg., 1-2 epith/HPF, occ. rbc/HPF, rare wbc/HPF. Hematology: wbc 6400, differential P60, L37, E1, M2, rbc normocytic, corr. sed. rate 30 mm/hr., hematocrit 39 percent. Blood chemistries: alk. phos. 4.9 units, BUN 17.8 mg percent, sugar 122 mg percent, Hinton neg. Electrophoresis(grams percent): TP 7.7, alb 4.8, TG 2.9, $\alpha 1$ 0.21, $\alpha 2$ 0.71, β 0.92, γ 1.03.
X-ray Findings: sketetal survey of skull, axial skeleton and of the bones of the extremities shows no evidence of radiation osteitis. The only abnormalities seen consist of a bilateral splay foot deformity with degenerative changes about the first metatarsal phalangeal joints. There is healed primary complex in the lung on the right side. Conclusion: no evidence of radiation osteitis.

(01-096) Born 17 August 1909. Present Health: good and has been in recent years except for some nervous indigestion. She is responding to treatment for this condition and feeling well. She had a gallbladder removed 5 years ago; no hospitalizations since that time.
Systems Review: no abnormalities of the eyes. Ears: slight deafness of the left ear since childhood as a result of an infection of the ear which caused a perforation of the drum. It still drains occasionally but causes no pain. Nose and Throat: normal. Neck: she has had some small posterior cervical glands on the left-hand side for many years. CR: negative. GI: she has had considerable difficulty with indigestion and gas over a period of years, with the gallbladder being removed 5 years ago. Now under medication from her physician which is very helpful. Bowels fairly regular, no history of any blood in the stools. GU: negative. Catamenia: menarche at age 14, periods regular until hysterectomy at age 29 shortly after the birth of her second child. She has had no hot flashes at any time. No vaginal discharge or staining at any time. NMS: some swelling and stiffness intermittently in both knees. No headaches, no paresthesias. Skin:

no abnormalities. Past History: usual childhood diseases, but no specific history of scarlet fever, rheumatic fever, or diphtheria. No allergies, epilepsy, or mental disorder. Operations as noted above. Hysterectomy at age 29, gallbladder removed at age 45, removal of cartilage of left knee at age 17, tonsillectomy at 19. No fractures or injuries. Family History: father died at age 75 of cancer of the rectum; mother, age 80, living, had presumed cancer of the breast removed 1 year ago. Seven siblings living and well. Family history of cancer as noted above. No family history of diabetes, tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married 24 years to the present time. Husband, age 58, living and well. One child, age 21, living and well. Single other pregnancy died at 3 days, April 1938. No pregnancies since hysterectomy at age 29. Dental History: has had only moderate amount of trouble with teeth and has approximately 22 remaining at this time. Gradually lost the others over the years. No trouble with healing after extractions. Radiation Exposure: painted watch dials from 21 February 1927 to 21 March 1932 and intermittently in 1935 - 1936. At this time no tipping of the brush in the mouth was done. She did notice occasional glowing of the hair and clothing at night. Physical Examination: a robust, healthy-appearing woman of 50, weight 184 lbs., BP 112/74, pulse 80 and regular. Eyes: pupils and extraocular movements normal. Ears: right ear normal, small amount of mucous drainage from perforation of left drum. Only slight diminution of hearing with tuning fork. Nose and Throat: normal. Remaining teeth in good repair, wears partial upper plate. Neck: there is a slight fullness in the anterior neck region which may be a slightly enlarged thyroid. This is not absolutely certain because of obesity. Heart and Lungs: normal to auscultation and percussion, rhythm regular, no murmurs heard. Breasts: normal female, no masses felt. Abdomen: somewhat obese; well-healed scars from previous cholecystectomy and hysterectomy. Pelvic and Rectal: not done. Reflexes: equal and active. Extremities: normal. No skin abnormalities.
Lab. Findings: Urinalysis: sp. gr. 1.030, albumin neg., sugar neg., mod. amount mucus, 0-2 epith. cell, 0-1 wbc/HPF. Hematology: wbc 6700, differential P52, L43, M3, B2, rbc normocytic, platelets normal, corr. sed. rate 24 mm/hr. Blood chemistries: sugar 72 mg percent, BUN 19 mg percent, alk. phos. 4.5 units, Hinton negative. Electrophoresis (grams percent): TP 7.5, alb. 4.33, TG 3.16, $\alpha 1$ 0.43, $\alpha 2$ 0.64, β 0.93, γ 1.16.
X-ray Findings: skeletal survey shows no evidence of radiation osteitis. There is thickening of the mucoperiosteum of both antra most likely on the

basis of chronic sinusitis. Degenerative changes consistent with patient's age are seen in dorsal and lumbar spine, and both tibias and fibulas. The patient has an anomaly, so-called supracondylar process,which is of no clinical significance.

(01-112) Born 20 February 1908. Worked as a dial painter from 26 March 1924 to 16 March 1926 and intermittently from 30 March 1926 to 29 July 1935, starting at age 16. In mid-1953 she had intermittent pain in her right shoulder and by the end of that year the pain had become persistent and there was considerable swelling of the upper arm extending to the shoulder joint. Examination in 1954 showed her liver to be enlarged and slightly tender but it was felt this was not metastasis. No enlarged nodes were found in the neck or axilla and she had no cough or history of trauma but there was mild ankylosis of both hips. X-rays revealed what appeared to be a subperiosteal fibrosarcoma with new bone being laid down in the tumor. An intrascapular thoracic amputation of the right arm was performed in May 1954 and a diagnosis of osteogenic sarcoma with axillary metastases was made. She was treated with P^{32} and later developed cough and fluid in the left chest. Toward the end of 1954 she was treated with radioactive chromic phosphate. She died 11 February 1955 of generalized carcinomatosis. No autopsy was performed.

(01-113) Born 26 February 1912. Present Health: good at the present time, except for a tendency to high blood pressure and deafness; both of these conditions are not serious.
Systems Review. Eyes: wears glasses for reading only. Ears: has had varying degrees of deafness since the age of 23. She believes that this was aggravated by multiple boils, in and about the ears, in her late twenties; she has had none of these infections in the past 10 years. She has been wearing a hearing-aid in the left ear for the past 4 years. No abnormalities of the nose and throat. No history of swollen glands in the neck or elsewhere. CR: some dyspnea on exertion, otherwise no complaints, except for the high blood pressure, which she has known about for at least 2 years, when it was discovered at a life insurance examination. She has been under treatment for the high blood pressure during the past 2 years. GI: occasional heartburn and indigestion, but no serious difficulties along these lines. Bowels regular without laxative, no history of any blood in the stools. GU: negative. Catamenia: menarche age 11, periods

still regular and normal at the present time, age 47. NM: negative, except for a tendency to headaches and nervousness. No skin abnormalities. Habits: appetite good, weight has fluctuated up and down in the recent years. Sleeps soundly at night. Smokes about 5 cigarettes daily, alcohol consumption averages two drinks a week. Most of her exercise is obtained doing housework. Past History: she had the usual childhood diseases, but no specific history of scarlet fever, diphtheria, or rheumatic fever. No history of epilepsy or allergy. No operations, accidents, injuries, or fractures. No confining illnesses. Family History: father died at 54 of a shock; mother, 81, living and well. Four siblings, living and well. One brother had tuberculosis 7 years ago, but has been well since that time. No family history of cancer, diabetes, allergy, epilepsy, or mental illness. Marital History: married 26 years to the present time. Husband, age 50, living and well. Three children, living and well, age 24, 19, 10. Dental History: she began to have trouble with her teeth in her late twenties, at which time she began to have some of them extracted. She had all of the remaining upper teeth extracted a few months ago. At the present time, she has twelve of her own teeth in the lower jaw. There was no trouble with healing of the jaw after extraction of the teeth. Radiation Exposure: at the age of 16 from 25 July 1928 to 1 September 1928, she painted clock dials. They were warned not to put the brush in their mouth and she remembers distinctly that she did not do this. She does not remember any glowing of the hair or clothing at night.

Physical Examination: a well-developed and nourished woman of 47, weight 135 lbs., height 61", BP 190/100, pulse 100 and regular. Eyes: pupils and extraocular movements normal. Ears: both canals filled with cerumen; deafness moderately severe in both ears. Nose and Throat: normal. Remaining twelve teeth in good repair. Neck: no cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Abdomen: soft and relaxed. Liver and spleen not felt. Breasts: normal female, no masses felt. Pelvic and Rectal: not done. Extremities: normal, reflexes equal and active.

Lab. Findings: Urinalysis: sp. gr. 1.019, albumin neg., sugar neg., 18-22 epith/HPF, amorphous phosphates, occ phosphate crystal. Hematology: wbc 9200, differential P67, L30, M3, rbc marked hypochromia, corr. sed. rate 17 mm/hr., hematocrit 33 percent, plts. increased. Blood chemistries: alk. phos. 4.3 units, BUN 11.6 mg percent, sugar 157 mg percent, Hinton neg. Electrophoresis (grams percent): TP 7.2, alb. 3.7, TG 3.5, α_1 0.34, α_2 0.73,

β 1.15, γ 1.33.
X-ray Findings: skeletal series including the skull, axial skeleton, chest, and extremities shows no evidence of radiation osteitis. The heart and lungs are normal in appearance, and the only skeletal abnormalities consist of minor degenerative changes in some of the peripheral joints.

(01-115) Born 10 October 1908. Worked as a dial painter from 20 June 1924 to 15 October 1930. In March 1930 she was found to be positive by electroscope. She was admitted to the hospital in February 1944 with a diagnosis of chronic radium poisoning. For a period of five weeks she had had considerable pain in the entire left thorax and left arm. X-rays showed a slight irregularity in bone texture at the head of the left humerus which was considered sufficient evidence for a diagnosis of pathologic change. Over a period of years most of her teeth had become loose and dropped out so that at the time of admission she had only 4-5 teeth remaining, 2 of which were very loose. Buccal and pharyngeal mucous membranes were normal. She died 20 June 1944. No autopsy was performed. According to the death certificate the cause of death was radium poisoning.

(01-118) Born 25 February 1909. Present Health: good except for a tendency to pains in the joints present for the last 16 to 17 years, attacks of migraine, some nervousness, and tendency to hot flashes.
Systems Review. Eyes: wears glasses for close reading only, otherwise vision is good. No abnormalities of the ears, nose. Tendency to postnasal drip particularly in the winter months. In the past she has noticed some swollen glands in the neck over a period of years. She has not noticed these lately. CR: some cough in the winter months associated with the postnasal drip noted above. She is also subject to some palpitation but no chest pains or unusual shortness of breath. GI: digestion is excellent; no abdominal pains, nausea, or vomiting. Bowels are regular without laxatives, no blood in the stools. GU: has had a tendency to urinary urgency and frequency in the morning but not during the rest of the day, nocturia once a night, no history of any blood or pus in the urine. Catamenia: menarche at age 10. Periods regular until 1 year ago, now has a tendency to skip periods; pelvic examination done 2 years ago. NM: has been troubled with pains in the joints, particularly the hands, knees, and ankles for the last 16 to 20 years, just how long is not certain. In 1953 she was told that she did not have arthritis but fibrositis. She

was assured that this would never become a crippling condition. She has had various types of treatments which included gold injections at one time many years ago. At the present time she is subject to varying degrees of pain in the extremities nearly all of the time; however, she thinks it is worse in winter months than in the summer. The symptoms are controlled largely by aspirin and sometimes she takes sodium salicylate. She is also troubled with severe, one-sided headaches which she says are due to migraine; these attacks come on about every 6 weeks. She thinks they are slightly better in recent years than they used to be in the past; suspects there is some association between the migraine and the periods. Skin: main difficulty is a tendency to athlete's foot; received x-ray treatment at one time several years ago and at the present time the condition is fairly well controlled by the use of Desinex ointment. Habits: appetite good, no weight change in recent years. Sleeps soundly at night; smokes 1 package of cigarettes daily. Alcohol consumption averages 1 drink per week; no regular exercise. Past History: usual childhood diseases including scarlet fever and a questionable history of rheumatic fever for one episode 12 or 13 years ago. There is no history of any allergy, epilepsy, or mental illness. Operations: approximately 20 or 21 years ago she was operated on for what proved to be a ruptured appendix and adhesions around one tube. The tube and appendix were removed and 1 month later a follow-up operation was necessary because of more adhesions; at this time one ovary was removed. Thirteen years ago 1 nipple was removed surgically because of what she describes as chronic inflammation. One wonders if this may not have been Paget's disease of the nipple. In all events, 3 years later and now 10 years ago the other nipple was removed for the same reason. No other confining illnesses and no history of any fractures or accidents. Family History: father is 78 years old, living but very feeble and is now a total invalid, blind and deaf. He also had a cancer of the large bowel removed 10 or more years ago. Mother died at age 74 of complications of cancer of the large bowel and heart disease. There are no siblings. One grandmother had diabetes. No history of tuberculosis, allergy, epilepsy, or mental illness. Marital History: married 31 years to the present time. Husband, age 50, living and well. One child, age 16, living and well. Two miscarriages, 17 years ago and 15 years ago. No other pregnancies. Dental History: has not had any great deal of trouble with her teeth. She has lost only 6 or 7 permanent teeth to date, no trouble with healing after extractions. Radiation Exposure: painted watch dials from 1 October 1923

to 5 November 1923, age 14. She believes she worked for only 1 or 2 months. The brush was put in the mouth to point it which was the custom at that time. She does not remember any glowing of the hair or clothes when she returned from work.

Physical Examination: a robust, healthy-appearing woman in no apparent distress, weight 127 lbs., height 62", BP 130/72, pulse 78 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose: normal. Teeth: those remaining are in good repair, No cervical adenopathy at the present time, thyroid not palpable. Heart and Lungs: normal to auscultation and percussion. Breasts: surgical removal of both nipples, no masses felt in the breasts themselves. Abdomen: soft and relaxed, liver and spleen not felt. Well-healed scar in right lower quadrant at site of previous operations. Reflexes: equal and active. Extremities: some early hypertrophic arthritic changes of the terminal joints of the fingers; otherwise, no abnormalities. Pelvic and Rectal: not done.

Lab. Findings: Urinalysis: sp.gr. 1.023, albumin neg., sugar neg., 1-3 rbc/HPF, 8-10 epith/HPF, yeasts. Hematology: wbc 15,800, differential P80, L18, E1, M1, rbc normocytic, corr. sed. rate 15 mm/hr., hematocrit 40 percent. Blood chemistries: alk. phos. 4.1 units, BUN 18 mg percent, sugar 113 mg percent, Hinton neg. Electrophoresis (grams percent): TP 6.5, alb 4.0, TG 2.5, $\alpha 1$ 0.21, $\alpha 2$ 0.56, β 0.92, γ 0.77.

X-ray Findings: skeletal series of the skull, axial skeleton, and of the bones of the extremities shows no evidence of radiation osteitis. There is some thickening of the muco-periosteum of the right antrum, but no fluid level is seen and no bone destruction is visible; otherwise, the skull is normal. The dorsal and lumbar spine are normal, as is the pelvis. The heart and lungs show no abnormalities. The bones of the arms and legs show only minimal degenerative changes in the metatarsal joints and some interphalangeal joints. The remaining teeth are normal. Conclusion: no evidence of radiation osteitis.

(01-125) Born 7 December 1911. Present Health: considers herself to be in good health except that for the past two months she has been having her menstrual periods about every week. Two weeks ago she told her doctor, who gave her an injection which worked for about two weeks. On the 25th of July, she began bleeding again. Again saw her doctor who used another injection, but she is still flowing.

Systems Review. Head: rare headaches, no fits, no convulsions. Eyes:

wears glasses for reading, no diplopia. Ears: good hearing, no infections. Nose: sense of smell good. Throat: gets a serious sore throat about once a year; last such episode was one week ago. No dysphagia, no soreness of the tongue or mouth. Neck: no known goiter, prefers hot weather. Breasts: negative. CR: ankles will swell a bit if she is on her feet all day. No shortness of breath, no pneumonia, no hemoptysis. At odd times usually when resting, she will note a very difficult-to-describe flip in her chest. This lasts only for a second and does not leave her feeling ill or in any way distressed. Note the below-mentioned murmur. Also, patient has been told from time to time over the past several years that she has high blood pressure. GI: appetite fair, slowly over the years has gained weight. No history of jaundice. Gets prolonged attacks of nausea without vomiting which she describes as nervousness, and occasionally to bad odors to which she is very sensitive. Bowels move once a day, does not take laxatives. Does have an occasional enema, has seen no blood in her stools. GU: no known infections of her kidneys or bladder, note the below-mentioned renal colic in December 1958. Has nocturia one time, no dysuria. Catamenia: menarche at age of 13, periods were never regular. Always flowed about seven days, quite heavily. No hot flashes. See Present Health. Psychiatric: feels she is fairly stable, but recently thinks she is more touchy and irritable than usual and will cry easily. Extremities: no known rheumatism or arthritis, no cramps on walking. No varicose veins. Skin: negative. Neurological: negative. Past History: operations - appendectomy at age of 39. In December of 1958, following attacks of left-sided renal colic, she was apparently cystoscoped and has had no difficulty since. Serious illnesses: she does not recall ever having had rheumatic fever, but at the age of 30 she was told she had a murmur which was probably due to rheumatic heart disease. Allergies: none known. Habits: occasional alcohol, no tobacco, no medication save for above-mentioned injections. Sleeps about nine hours a night. Family History: father died at the age of 53 of a coronary; mother living, age 71, has arthritis. One brother and three sisters living and well. No diabetes, tuberculosis, etc. in the family. Marital History: is married, has four children, ages 26, 24, 20, and 17, all of whom are in good health. Dental History: has no dentures, has all of her upper teeth and only a few of her lower teeth left. Sees her dentist about once a year. Radiation Exposure: painted dials from 27 October 1927 to 8 December 1927, and also scraped mistakes in painting off the dials. The paint was dry and tended to flake up and adhere to her

face and hair. She does recall that her hands and head glowed at night. Physical Examination: height 63.5", weight 130 lbs., BP 175/98, pulse 64. Patient is a slender, well-developed, tanned, healthy-looking, well-preserved 47-year-old woman in no distress. Head: eyes - pupils equal, react to light and accommodation, extraocular movements normal, fundi within normal limits. Ears: drums negative, hearing good. Nose: negative. Mouth: tongue well papillated, slight injection of the left tonsillar fossa. Neck: carotids pulsating, small thyroid, no nodes. Breasts: no masses or tenderness. Lungs: resonant to percussion, good breath sounds, no rales. Heart: point of maximal impulse in the 4th left interspace just outside the midclavicular line. Has a grade 2, rather harsh, blowing, apical, systolic murmur. Second sound is loud at the apex. A2 is louder than P2 and has a snapping tambour-like quality. There is a moderately harsh systolic murmur at the aortic region which is transmitted to the neck vessels. Abdomen: flat, soft. There is a right lower quadrant appendectomy scar. No liver, kidney, or spleen felt. Has moderate tenderness to deep palpation in the right lower quadrant. Good femoral pulses. Rectal and Pelvic: not done. Extremities: good peripheral pulsations, no joint pathology, no edema. Skin: negative. Neurological: within normal limits. Diagnoses: menopausal bleeding, hypertension of unknown etiology, valvular heart disease which would require more extensive workup to elucidate.
Lab. Findings: Urinalysis: sp. gr. 1.013, albumin neg., sugar neg., 20-25 rbc/HPF (Pt. menstruating), 1-2 epith/HPF, 1-2 wbc/HPF. Hematology: wbc 7200, differential P64, L35, E1, rbc slight hypochromia, corr. sed. rate 20mm/hr., hematocrit 39 percent. Blood chemistries: alk. phos. 3.9 units, BUN 17 mg percent, sugar 119 mg percent, Hinton neg. Electrophoresis (grams) percent): TP 7.0, alb 4.6, TG 2.4, $\alpha 1$ 0.22, $\alpha 2$ 0.43, β 0.76, γ 0.99.
X-ray Findings: skeletal series shows no evidence of radium poisoning. Some sharply defined defects in the parietal bones probably represent unusually located Pacchionian bodies. The incisor teeth particularly the upper ones show sharply defined defects, ? porcelain fillings.

(01-126) Born 10 December 1903. Present Health: good and has been for many years, except for hypertension. She has been under treatment for hypertension since her late twenties and has taken medication steadily for this condition. She sees her doctor approximately 4 to 5 times a year for a checkup concerning this condition. She is also taking some medication for hot flashes.

Systems Review: no abnormalities of the eyes, ears, nose, or throat. She wonders whether she could be slightly deaf in her left ear. No specific complaints. Neck: no history of swollen glands of the neck or elsewhere. CR: normal. GI: negative. Bowels regular without laxatives. No history of any blood in the stools. GU: normal. Catamenia: menarche at age 16, periods regular until age 41 when they stopped in the course of 6 to 12 months. Following this she has had a great deal of trouble with hot flashes which have persisted in varying degrees up to the present time. NM: has had trouble with varying degrees of low back pain since the age of 21 and is treated fairly regularly by a chiropractor with benefit. She has rare headaches, used to be troubled with bursitis in the shoulders but none in recent years. No history of any fractures. No skin abnormalities. Habits: appetite good, weight has diminished some with diet. Sleep fair only. Smokes approximately one package of cigarettes daily, alcohol consumption minimal to none. She gets a fair amount of regular exercise. Past History: usual childhood diseases but no specific history of scarlet fever, rheumatic fever, diphtheria, allergy, epilepsy, or mental disorder. Marital History: married for the first time approximately 38 years ago at age 19, husband died in 1 year of tuberculosis. No pregnancy resulted from this marriage. Married for the second time 29 years ago to present, husband aged 55 living and well. No pregnancies because of known and definite sterility on the part of the husband. Dental History: began to have trouble with her teeth two or three years after starting to paint watch dials. The front teeth were those first involved, many cavities. Gradually the gums became involved, eventually the teeth loosened requiring extraction. As a result all teeth were missing by age 38. States very definitely that there was no difficulty with healing after extraction. Dietary History: as far as the patient can remember she was always fond of milk and other dairy products and ingested adequate amounts of these items, such as milk, eggs, cheese, and butter. She is fond of fruit and vegetables, adequate amount of meat in diet. No particular likes or dislikes. Radiation History: started painting luminous dials at the age of 19. Starting date was 6 February 1922 continuing to 1931 with the exception of 1 year following her marriage in 1930. For the first 5 years she pointed the brush regularly in her mouth, as all of the other workers did. She definitely remembers glowing of the hair and clothing at night after work. She admits that she probably painted her teeth, ear lobes, fingernails, etc. during the early years of her employment.

Physical Examination: a well-developed and nourished woman in no apparent distress, weight 115 lbs., height 62", BP 210/90, pulse 88 and regular. Eyes: pupils and extraocular movements normal; fundi show tortuosity of the vessels and AV nicking bilaterally. Ears: negative. No gross hearing loss. Nose and Throat: normal. Teeth all removed with full upper and lower dentures. Neck: no palpable thyroid or other glandular enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female. Abdomen: soft and relaxed, liver and spleen not felt. Inguinal rings normal. Pelvic and Rectal: not done. Extremities: varicose veins 1+ anterior aspect of left leg, otherwise negative. Reflexes: equal and active.

Lab. Findings: Urinalysis: sp. gr. qns, albumin neg., sugar neg., 0-4 epith cells/HPF, rare wbc/HPF. Hematology: wbc 11,000, differential P71, L26, E3, rbc normocytic, corr. sed. rate 13 mm/hr. Blood chemistries: alk. phos. 4.6 units, BUN 21 mg percent, sugar 104 mg percent, Hinton neg. Electrophoresis (grams percent): TP 6.5, alb 3.75, TG 2.74, $\alpha 1$ 0.40, $\alpha 2$ 0.51, β 0.87, γ 0.96.

X-ray Findings: there are multiple areas of rarefaction in the frontal, parietal and occipital bones, some of which are over 1 cm in diameter - score 2+. There are minimal areas of bone resorption in the ischia and iliac bones. There is equivocal evidence of coarsening of bone trabeculation, but not enough to be definite - score 1+. There are small areas of rarefaction less than 10 mm in diameter and some coarsening of trabeculation on the upper shaft and femoral neck bilaterally - score 2+ each. There are areas of rarefaction in both the tibia and fibular bilaterally. A few are slightly over 1 cm in diameter - score 2+ each. Both humeri show rarefactions which are less than 1 cm in diameter - score 1+ each. Rarefactions are present in both radii and ulnae less than 1 cm in diameter - score 1+ each. There are degenerative changes consistent with the patient's age present in the cervical, dorsal, lumbar spine. The L4-5 interspace is narrowed, and calcium is noted in the abdominal aorta. The lungs are normal. The heart is just above the upper limits of normal in size with a transverse diameter of 14 cm compared to a thoracic diameter of 26 cm. Its configuration suggests the left ventricle accounts for the enlargement. Skull base including facial bones, mandible, both feet and ankles, both hands and wrists negative for radiation changes. Conclusion: mild radiation changes as seen in the skull, pelvis, and extremities. Total Score: 15F.

(01-127) Born 8 January 1908. Present Health: good at the present time and has been since she had a hysterectomy in October 1957.
Systems Review: no abnormalities of the eyes. Ears: subject to question of Menière's disease for about two years intermittently from 1955 to 1957. She has little or no trouble with this illness since her hysterectomy. No disorders of the nose or throat. No history of any swollen glands of the neck or elsewhere. CR: she was told some time ago that she had a scar on one lung showing an old healed tuberculosis. She has never experienced any difficulty, either subjectively or objectively. She is subject to occasional mild pains in the precordial region after exertion, such as walking up a hill. The pain goes away very promptly with rest. No cough at the present time. No history of any edema. GI: entirely negative. Bowels regular without laxatives. No history of any blood in the stools. GU: negative. Catamenia: menarche at age 15, periods fairly regular until hysterectomy at age 49. At this time she had a very large fibroid tumor removed. She has had moderately severe hot flashes since the hysterectomy. NM: she used to be subject to vague intermittent joint pains, particularly in the shoulders; but since she had her teeth all removed one year ago she has had no further difficulty along this line. No skin abnormalities. Habits: appetite good, weight has gradually increased during the past few years. She sleeps soundly at night, does not smoke, no alcohol consumed. Her exercise consists chiefly of housework. Past History: had the usual childhood diseases and scarlet fever as well. No history of diphtheria, rheumatic fever, allergy, epilepsy, or mental illness. Operations consist of appendectomy at age 15, hysterectomy at age 49. Fracture of the right elbow at age 15, also a fracture of two lumbar vertebrae at age 21 at which time she was hospitalized for a period of 3 months in a plaster cast. She has had no trouble since that time in connection with the back. Family History: father died at age 56 of heart disease; mother died at 56 of a shock and heart trouble. One sister died at 27 of tuberculosis. One brother is living with healed tuberculosis, doing well at the present time. Three other siblings are living and well. No other members of the family had tuberculosis. No history of cancer, diabetes, allergy, epilepsy, or mental disorder. Marital History: married 28 years to the present time. Husband, age 52, living and well. Three children, ages 26, 24, 22; all are married and have at least 1 child of their own. There was 1 child who died in infancy between the first two children, presumably of a birth injury. Dental History: had little or no trouble with her teeth until approximately

4 to 5 years ago when they began to loosen up. A few came out during the next two years, and then 1 year ago she had them all removed. Radiation Exposure: painted clock dials from 17 October 1927 to 20 December 1927 at the age of 19. She remembers tipping the brush in her mouth only occasionally, and she also remembers that her hair and clothing glowed at night when she got home. Also remembers painting fingernails and ear lobes as a joke while at work.

Physical Examination: a well-developed and rather overweight individual of 51, height 61.5", weight 172 lbs. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Teeth all removed with full upper and lower dentures. Neck: no cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: very obese. Well-healed scar in the lower midline region and in the right lower quadrant. Liver and spleen not felt. Pelvic and Rectal: not done. Extremities: superficial varicosities, otherwise normal. Reflexes: equal and active.

Lab. Findings: Urinalysis: sp. gr. 1.020, albumin neg., sugar neg., 20-30 wbc/HPF, 3-5 rbc/HPF. Hematology: wbc 8500, differential P66, L32, M2, rbc normocytic, corr. sed. rate 22 mm/hr., hematocrit 42 percent. Blood chemistries: alk phos. 5.8 units, BUN 14.9 mg percent, sugar 87 mg percent, Hinton neg. Electrophoresis (grams percent) TP 7.4, alb 4.3, TG 3.1, $\alpha 1$ 0.33, $\alpha 2$ 0.67, β 1.01, γ 1.09.

X-ray Findings: skeletal survey and films of the chest show no evidence of radium poisoning. The only skeletal abnormalities seen are minimal degenerative changes consistent with the patient's age. The heart is at the upper limits of normal in size.

(01-132) Born 6 November 1908. Painted watch dials from 3 December 1923 to 8 September 1925. She was married on 18 November 1933 and was said to have been perfectly well up to that time. Two children were born, one in 1934 and one in 1936. Following the second pregnancy she developed pain and stiffness in both hips which gradually became so severe that she was unable to get out of her chair. After various types of treatment by chiropractors and local physicians she was admitted to the hospital and was put in Buck's extension. Her teeth started to loosen in 1938 and within 6 years she had become completely edentulous. Examination in 1938 revealed pain and lameness of the left wrist, exaggerated reflexes, ankylosis of the hip with the right hip being absolutely rigid.

She was readmitted to the hospital in January 1944 for left facial paralysis. She was said to have had otitis media on the left for a number of years and was very hard of hearing. Laboratory studies at this time: urinalysis within normal limits except for many wbc/HPF, hgb 88 percent, 12.8 g, rbc 4.3, wbc 7800, P72, Ps 2, L24, M2. X-rays revealed an area of destruction 3 cm in diameter seen in the skull near the coronal suture. Two small areas of destruction were seen in posterior part of skull. The mastoids were large; the cells were small. Irregular areas of destruction were noted in the mastoids more extensive on the left. There was an absence of inflammatory reaction. The bone texture of pelvis and upper ends of femora was abnormal. The epiphysis for each iliac crest showed interference with fusion, indication of heavy metal poisoning at about eighteen years of age. There was destruction at the head of each femur and almost complete destruction of the hip joint on each side. Diagnosis: radium poisoning. On 20 July 1944 she was again readmitted to the hospital because of hemorrhage of the left ear.

Physical Examination: patient was a well-developed, well-nourished, white woman who appeared to be chronically ill and who was stone deaf. She was alert and well oriented. EOM normal. Pupils round, regular, and react to light and accommodation. Ears: there was absolutely no hearing whatsoever. The right ear appeared fairly normal on examination; however, in the left ear was an enlarged foul-smelling cavity replacing the bony canal of the ear and there was dried blood in this cavity. She also complained of pain in this ear. Nose: adequate airway and no discharge. Mouth: there was a marked droop to the left corner of the mouth. No teeth. Mucosa normal and somewhat pale. Breasts: no masses or tenderness palpable. Lungs: resonant to percussion throughout both lung fields. Breath sounded vascular to bronchovasicular. No rales or ronchi heard. Heart: normal size to percussion. No shocks or thrills were palpated. Sounds were of good quality. Rate was rapid and the rhythm was regular and no murmurs were heard. Abdomen: somewhat obese, soft, No masses or tenderness were made out. No organs were palpable. Skin: somewhat pale; however, it was warm and of good turgor. No signs of edema; sclerae and conjunctivae clear. Neurological: revealed physiological tendon reflexes. No gross sensory change aside from facial distribution about the left ear and left side of face. No Babinski. Impression: chronic radium poisoning with erosion of left portion of temporal bone resulting in hemorrhage due to the erosion of blood vessels in this area. She died on 7 August 1944. Autopsy revealed necrosis

of left temporal bone with infection, left temporal lobe abscess, suppurative meningitis, ankylosis of the hips.

(01-136) See case 01136 of M.I.T. progress report (AECU-4285) May 1959.

(01-146) See case 01146 of M.I.T. progress report (AECU-4285) May 1959.

(01-149) See case 01149 of M.I.T. progress report (AECU-4285) May 1959.

(01-155) Born 25 October 1900. Present Health: he "medically feels fine, physically poor". In 1954 the patient was driving his car when without any warning, he noticed that his left hand slipped off the wheel. This was the onset of the left-sided paralysis. He denies headaches, there was no loss of consciousness, no trouble with his vision, but he had some difficulty in speaking. The etiology of this is quite obscure. He was said upon admission to the hospital to have high blood pressure. His family physician at the time said that he had arteriosclerosis. He spent 12 weeks in a private hospital and since then has had 6 different admissions to a veterans hospital. At present he is unable to work. He gets around by means of a cane and a wheelchair. His left arm is completely useless to his. Systems Review. Head: denies the occurrence of headaches; no fits, no epilepsy. Eyes: far-sighted and wears glasses. No diplopia. He says his fields of vision are normal. Ears: hearing good, no known ear infections, no dizziness. Nose: no epistaxis, sense of smell good. Mouth: no dysphagia, no trouble with speaking now, no soreness of mouth or tongue. Neck: no history of goiter. CR: no shortness of breath, no ankle edema, no chest pain. Note that he was said to have had high blood pressure after his cerebral vascular accident. No history of rheumatic fever or of heart murmurs. GI: he says that at the time of his kidney stones, 2 years ago, he lost a lot of weight but has now regained this and his weight is more or less constant. Appetite poor. He has no food dyscrasias. No abdominal pain, no gas, or discomfort. No history of yellow jaundice. Moves bowels about every second day, no bleeding. Uses Exlax for a laxative. GU: see above note. No recent kidney stones, dysuria, or nocturia. Extremities: no known rheumatism or arthritis. No varicose veins. Neurological: see history above. Habits: has smoked pipes and cigars since the age of 12. Slight alcohol intake. He takes no medications except for Exlax every 3rd day. Sleeps 10 hours a night. Past History: operations - kidney stones were removed through a cystoscope about 2 years ago. Serious illnesses: pneumonia of unknown etiology at the age of 33. Allergies: none. Family History: father died at the age of 42 of tuberculosis of the bone; mother died at the age of 54 of a ruptured appendix. Two brothers and two sisters living and well. No diabetes in the family. Marital History: married and

and has 5 children all of whom are living and well. One girl had polio at the age of 12 but is now fully recovered. Dental History: about 10 years ago had most of his teeth pulled and now has complete upper plates and a partial lower plate. Radiation Exposure: is not aware of ever having been exposed to any type of radiation, but in one of his workups at the veterans hospital he was given a radioactive substance diagnostically to see if his left hemiparesis was due to a brain tumor.

Physical Examination: a medium-sized, rather slender, 58-year-old man who looks generally healthy but who is obviously disabled with a paralysis of his left arm and a paresis of his left leg. He wears a brace on his left leg to prevent foot drop; height and weight not obtained because of obvious difficulties in ambulation, BP 160/106, pulse 76. Head. Eyes: pupils equal, react to light and accommodation. Has a well-developed corneal arcus. Extraocular movements normal. Has a symmetrical, slightly narrowed field of vision by gross confrontation. Fundi show minimal arteriosclerotic changes. Ears: impacted cerumen on the right, normal drum on the left. Cannot hear the high-pitched ticking of a wrist watch in either ear. Nose: negative. Mouth: complete upper and partial lower plates. Has a black tongue; protruding tongue is slightly to the right. Symmetrical mouth. Neck: carotids both pulsating. No nodes or masses. Lungs: resonant to percussion, some reduced motion on the left side. Good breath sounds, no rales. Heart: not enlarged to percussion, good tone, no murmurs; A2 equals P2. Abdomen: no scars, somewhat tense. Liver, kidney, or spleen not felt. No tenderness. No inguinal hernias. Genitalia: testes both descended, no masses. Rectal: no external hemorrhoids. Extremities: no ankle edema, no dorsalis pedis, or posterior tibial pulses felt. Marked atrophy of the musculature of the left arm. Neurological: no demonstrable weakness of the left 7th nerve. Has markedly hyperactive deep tendon reflexes on the left with sustained clonus of the left ankle and a positive Babinski on the left. Save for gross movements of the left shoulder girdle has an absolute paralysis of the left arm. Paresis of the left leg. Skin: no abnormalities.

Lab. Findings: Urinalysis: sp. gr. 1.010, albumin 1+, sugar neg., 20-25 rbc/HPF, loaded with wbc and bacteria/HPF. Hematology: wbc 7800, differential P58, L38, E4, rbc normocytic, corr. sed. rate 12 mm/hr, hematocrit 49 percent. Blood chemistries: alk. phos. 4.3 units, BUN 12 mg percent, sugar 91 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.0, alb 4.5, TG 2.5, $\alpha 1$ 0.2, $\alpha 2$ 0.5, β 0.8, γ 1.0.

X-ray Findings: skeletal series shows some cerebral arteriosclorosis. There is calcification in the region of the right greater tuberosity (bursitis).

The liver and spleen appear abnormally dense. This is probably due to Thorotrast administration. The heart and lungs are normal in appearance. The long bones and other bones of the extremities show no abnormalities with the following exceptions: the left patella is unusually dense. This could be Paget's disease limited to the patella. Conceivably it could represent radium necrosis. There appears to be some degeneration about the laft hand and wrist joint with an increase in density of some of the carpal bones. Conclusions: there are some critical changes in the left patella and in the left wrist. Apparent abnormally dense liver and spleen probably due to a Thorotrast administration in the past.

(01-161) Born 5 October 1896. Present Health: good and has been in recent years.
Systems Review. Eyes: occasional shooting pains in left eye; this has never been prolonged or serious. Ears: some pain in right ear in the past, but none in recent months. Hearing very acute. Nose: patient states that she has always complained of varying degrees of soreness of the nose. Frequent investigations have never revealed any source for this pain. Throat: negative. Neck: no history of any swollen glands of the neck or elsewhere. CR: negative except for some substernal pain when she is in a hurry. She attributes this to a hiatus hernia. GI: negative except for hiatus hernia just mentioned. Bowels tend to be constipated; this she attributes to diverticulosis. She is in the habit of taking frequent enemas to relieve this constipation. No history of any blood in the stools or melena. GU: nocturia one to two times per night for many years. No other complaints. Catamenia: menarche at age 11, periods fairly regular until age 42 when she received x-ray treatment to the ovaries, resulting in an artificial menopause. She had some hot flashes after this treatment which were relieved by hormonal therapy. NM: some pains in the lower back attributed to arthritis of the spine. Occasional pain, but no swelling, in some of the other joints of the extremities. She is bothered by occasional numbness and tingling of the hands and feet for which she takes nicotinic acid and other vitamins. Skin: she used to have considerable trouble with some type of possibly allergic dermatitis, but this was treated successfully with Benadryl. No trouble in recent years. Past History: childhood diseases consisted of measles and whooping cough only. No history of diph-

theria, scarlet fever, or rheumatic fever. Questionable degree of food allergy. No history of epilepsy or mental disorder. Operations consist of tonsillectomy in 1919, had an operation for fistula-in-ano in 1940, and a cholecystectomy and appendectomy in 1955. Family History: father died of hypertension, age 49; mother, 87, living and reasonably well. No siblings. No family history of cancer, diabetes, or tuberculosis, Many members of the family have a tendency to allergy. No history of epilepsy or mental disorder. Marital History: married 40 years to present time. Husband, 68, living and well. There were two premature births; both babies died, one when she was age 24, and the other when she was age 28. No other pregnancies by design. Dental History: she first lost two wisdom teeth in 1920, and then in 1934 to 1936, fourteen other teeth were extracted. No trouble with healing after extractions. Radiation Exposure: she was employed for a period of 3-4 months in 1918 at the age of 21 as a dial painter. She remembers putting the brush in her mouth regularly to point it. She does not remember any luminescence of the hair or clothing at this time.

Physical Examination: a well-developed and somewhat overweight woman, weighing 171 lbs., height 60", BP 180/110, pulse 90 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Remaining 15 teeth in fair state of repair. Neck shows no cervical adenopatny. Thyroid is palpable, but not particularly enlarged. No evidence of thyrotoxicosis, such as tremor or lidlag. Heart: normal to percussion. There is a soft grade-1 systolic murmur in the aortic area, probably of no significance. Lungs: clear and resonant. Breasts: normal female, except for possible cystic change in the left breast at 2 o'clock. Abdomen: a well-healed scar on right side, site of cholecystectomy and appendectomy. No masses felt. Liver and spleen not made out. Pelvic and Rectal: not done, at patient's request. Extremities: essentially negative. Reflexes: equal and active. No skin abnormalities.

Lab. Findings: Urinalysis: sp. gr. 1.008, albumin neg., sugar neg., 4-6 rbc/HPF, 6-8 epith/HPF. Hematology: wbc 5000, differential P40, L53, E3, M4, rbc normocytic, corr. sed. rate 12 mm/hr., hematocrit 44 percent. Blood chemistries: alk. phos. 6.1 units, BUN 15 mg percent, sugar 102 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.9, alb 4.6, TG 2.3, $\alpha 1$ 0.17, $\alpha 2$ 0.47, β 0.75, γ 0.93.

X-ray Findings: skeletal survey fails to show any evidence of radium poisoning. Incidental finding is a 3 x 4 cm area of calcification in the

in the right side of the pelvis, consistent with a calcified fibroid of the uterus.

(01-166) Born 24 April 1897. Present Health: her health is fair only, because of what she describes as a heavy feeling in the head and occasional severe headaches which have been stated to be due to congestion in the ethmoid sinuses. She plans to have an operation this fall for opening up the ethmoid sinus. She also complains of pains in the right ankle when she walks on any sort of uneven ground. She wonders if she will have the same difficulty with the right ankle as she did with the left which required an arthrodesis when she was 46.
Systems Review. Eyes: troubled with a diminution of vision when she is troubled with the pressure in the head due to the sinus disturbance. Ears: some dizziness on change of position in varying amounts from time to time. Nose: she states that she has had some trouble with polyps every few years and sometimes requiring operation. At the present time these seem to be in abeyance. No difficulties with the throat. Neck: no history of any swollen glands or thyroid enlargement. CR: negative. GI: normal except for an allergy to shellfish. Bowels are regular without laxatives; no history of any blood in the stools. GU: one episode of dysuria and frequency when she took an excessive amount of fruit juice. Catamenia: menarche at age 13; periods regular till age 19. Following that time they were very irregular till the age of 32 when a hysterectomy was done together with the removal of one ovary, supposedly for chocolate cyst. She has been troubled some with hot flashes since the time of that operation; these are still present to a certain degree. NM: see Present Health. The arthrodesis done on the left ankle seems to be doing well. She now is troubled with the right ankle for the past nine months. See above. She also has some difficulty with pains in the maxillary region of the left side of the face. This has been present for many years. No skin abnormalities. Habits: appetite is too good; tendency for weight to go up, but for the past five years with diet it has remained the same. Sleeps fairly well except for difficulty with the heavy feelings in the head also noted in Present Health. She does not smoke. Alcohol consumption is nil. Exercise consists chiefly of housework. Past History: does not remember having had any of the childhood diseases; specifically no history of scarlet fever, diphtheria, or rheumatic fever. Her only allergy is to shellfish. No history of any epilepsy or mental disorders. No accidents, fractures, or other hospital-

izations. She had an operation on the left upper jaw at the age of 24 for so-called phosphorus poisoning. Family History: father died at 90 of a stroke; mother died at 88 of a stroke. Two siblings living and well. Five siblings who died; two were killed in accidents and one died in infancy of tuberculosis and one died at the age of 18 months and another died of influenza in childhood. No family history of cancer, diabetes, allergy, epilepsy, or mental disorder. Marital History: married 41 years to the present time. Husband is 64, living and well. There are 4 children, living and well, all married and 11 grandchildren. Dental History: five years after dial painting she had all of her teeth removed at the age of 24. There is a question of whether there may have been some osteomyelitis of the mandible requiring the operation noted above. Since that time there has been no further difficulty of a dental nature. Radiation Exposure: in 1916 at the age of 19 she went to work for a period of 6-7 months painting watch dials. She tipped the brush regularly in her mouth. She stopped this employment because of fainting spells, and she was told she was quite anemic at the time. She does not remember any particular luminescence of fingers or clothing. She had no further contact with the radium industry after this episode.

Physical Examination: a well-developed and nourished woman in no apparent distress, weight 140 lbs., height 65", BP 180/80, pulse 82 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose: normal. Throat: normal. Teeth were all removed; wears full upper and lower dentures. Neck: no cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses noted. Abdomen: soft and relaxed, liver and spleen not felt. Pelvic and Rectal: not done. Extremities: normal except for slight tremor of the hands. Also it should be noted the left ankle is fixed from the arthrodesis as noted in the history.

Lab. Findings: Urinalysis: sp. gr. 1.015, albumin neg., sugar neg., occ wbc/HPF, occ epith/HPF. Hematology: wbc 6700, differential P60, L30, E7, M3, rbc normocytic, corr. sed. rate 11 mm/hr., hematocrit 42 percent. Blood chemistries: alk. phos. 9.5 units, BUN 17.2 mg percent, sugar 105 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.4, alb 3.81, TG 2.58, $\alpha 1$ 0.26, $\alpha 2$ 0.37, β 0.61, γ 1.34.

X-ray Findings: skeletal series shows extensive bilateral antral sinusitis. Only a Waters view of the sinuses is made, and there may be sinusitis in the frontal and ethmoid sinuses as well. The skull shows no evidence of rad-

iation osteitis. The patient is edentulous. The heart is normal. There are some linear scars in the right first interspace probably due to old tuberculosis. The dorsal and lumbar spine show minimal degenerative changes. The rest of the skeleton is normal with the exception of the left foot, where there appears to have been some sort of arthrodesis. If this has not been done, then there is marked narrowing of all the joint cartilages most likely due to arthritis. Some degenerative changes are seen in the right foot. No evidence of radiation osteitis is seen in the skeleton.

(01-172) See case (01172) M.I.T. progress report (AECU-4285) May 1959.

(01-179) See case (01179) M.I.T. progress report (AECU-4285) May 1959.

(01-183) Born 3 September 1900. Present Health: fairly good except for chronic rheumatoid arthritis present for the last four years. She had a cholecystectomy two years ago from which she has made a good recovery. Systems Review. Eyes: no abnormalities, does not wear glasses regularly. Ears, Nose, and Throat: normal except for tendency to sore throat when the rheumatism flares up. She is subject to neuralgia of the face from time to time. CR: negative. GI: negative since cholecystectomy two years ago noted above. Bowels fairly regular with attention to diet. Takes bran fairly regularly. GU: negative. Catamenia: menarche at age 16, periods regular until age 50, no flow since that time. Is troubled moderately with hot flashes. NM: no disorders of any sort until four years ago when she began to have severe rheumatoid arthritis which has varied in severity since that time. She was hospitalized for 10 weeks at the time of the onset in 1956, and for another 10 weeks in 1957. She is now taking vitamins, iron, and one Medrol tablet three times a day. Skin: no abnormalities. Habits: appetite good, weight has gone up with cortisone therapy. Sleeps fairly well, occasionally has to take sleeping pills. Does not smoke, alcohol taken only occasionally. Past History: usual childhood diseases but no specific history of scarlet fever, rheumatic fever, diphtheria, allergy, epilepsy, or mental illness. Contracted lues towards the end of her first marriage in 1924. Had intensive therapy with arsenicals and bismuth for a period of two years. There has been no recurrence. No history of any fractures, accidents, or injuries. Operations consist of cholecystectomy noted above, appendectomy in childhood, and presumably some type of gynecological operation at age 24 or 25. Marital History: married for the

first time for four years, 1920-1924, at age 20. One child, now 39, living and well, who is married and has children of her own. Second marriage in 1940 at age 40 for 19 years to the present time. No pregnancies. Husband, 51, living and well. Dental History: lost her first two teeth by extraction at age 26, at which time a lot of pus drained from the sockets of the removed teeth. There was some difficulty with healing of the sockets following the extractions. Since that time she has lost several more teeth, but has had no difficulty with healing after the extractions. She has approximately 16 of her permanent teeth remaining. Radiation Exposure: at the age of 14 or 15, she was employed for approximately 1.5 years painting luminous dials starting in 1915. They were taught to point the brush in the mouth and she did this regularly for the full months of her dial painting. She eventually left this type of work because of the onset of severe sore throat which took several months to heal. About 1927 she remembers being tested for the presence of radon in the breath. There was also some type of geiger counter put on her thighs. She does not know what were the results of these tests.

Physical Examination: a well-developed and nourished woman of 59 with somewhat moon-shaped facies, presumably due to cortisone therapy, weight 135 lbs., height 64.5", BP 118/76, pulse 82 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Remaining teeth in fair state of repair with partial upper and lower plates. Neck: no cervical adenopathy. Thyroid not palpable. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: soft and relaxed. Liver and spleen not made out. There is a fairly recent scar in the right upper quadrant from the previous cholecystectomy. Well-healed older scars in right lower quadrant and lower midline. Pelvic and Rectal: not done. Extremities: marked arthritic changes in both hands and wrists with some deformity of the fingers. Moderately severe arthritic changes of the feet, particularly in the toes. There is some involvement of the knees, more marked on the right than on the left. Limitation of motion in the hands only, at this time. Reflexes: equal and active. Romberg test negative.

Lab. Findings: Urinalysis: sp. gr. 1.020, albumin neg., sugar neg., 6-10 wbc/HPF, 2-4 epith/HPF, 1-2 rbc/HPF. Hematology: wbc 6200, differential P82, L15, E2, M1, rbc normocytic, corr. sed. rate 38 mm/hr., hematocrit 42 percent. Blood chemistries: alk. phos. 4.4 units, BUN 19.2 mg percent,

sugar 96 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.4, alb 3.7, TG 2.5, α1 0.29, α2 o.57, β 0.81, γ 0.86.
X-ray Findings: left tibia and fibula show some small punched-out areas of radiolucency. The appearance is equivocal, but consistent with radiation changes, + or -. There are small punched-out areas of decreased density and a patch of sclerosis near the metaphysis of the upper end of the right tibia, score 2+. There are punched-out areas of bone resorption less than 1 cm in diameter present in the right humerus (score 1+) and in both radii and ulnae, score 2+ each. Both hands and wrists are negative for radiation changes. The patient appears to have rheumatoid arthritis. The heart is near the upper limits of normal. The aorta shows some calcification. No pulmonary disease is seen. There are deposits of heavy metal in the buttocks in either side. Impression: minimal radiation changes. The abnormalities in the upper extremities may be to some extent influenced by the fact that the patient has rheumatoid arthritis which may lead to rather extensive osteoporosis by itself. Total Score: 5-1/2.

(01-188) See case (01188) M.I.T. progress report (AECU-4285) May 1959.

(01-193) See case (01193) M.I.T. progress report (AECU-4285) May 1959. Patient died in March 1960 of coronary disease.

(01-200) Born 8 May 1910. Present Health: good and has been in recent years. Her only illness was an attack of what she called "pleurisy" of the left chest, lasting for about three weeks in May 1959.
Systems Review. Eyes: wears glasses for reading, otherwise normal. Ears, Nose, and Throat: negative. No history of any swollen glands in the neck or elsewhere. CR: some chronic cough which she attributes to cigarettes. She had an attack of pleurisy with fever, as noted above, in May 1959. No x-rays were taken. No history of any chest pain or cardiac symptoms. GI: occasional feeling of tightness in the epigastrium when she gets nervous. Gallbladder x-rays were taken and found to be normal five years ago. Bowels regular, no history of any blood in the stools. Catamenia: menarche at age 14, regular until age 42 when they stopped completely. She was troubled with some hot flashes at that time, none in recent years. No history of any bleeding or discharge since that time. NM: normal. Skin: no abnormalities.
Habits: appetite good, weight has dropped off about 15 lbs. in the last two years, but no recent weight loss. Sleeps soundly at night. Smokes.

approximately one package of cigarettes daily. Alcohol consumption averages two glasses of beer daily. Gets moderate amount of exercise at work. Past History: usual childhood diseases. No specific history of diphtheria, scarlet fever, or rheumatic fever. No history of any allergy, epilepsy, or mental disorder. No operations, accidents, or injuries. No hospitalizations. Family History: father died at age 66, cause undetermined. Mother died at age 70 of heart disease. Seven siblings living and well. One brother died at the age of 42 of coronary thrombosis. Mother had diabetes. No family history of epilepsy, mental disorder, cancer, or tuberculosis. Marital History: married in 1935 at age 25 until husband died at age 40 in 1950 from some type of a tumor. Two children, ages 21 and 18, living and well. No other pregnancies, cause not known. Radiation Exposure: worked from 6 November 1925 to 11 April 1929 inspecting clocks and from 5 June 1930 to 7 April 1931 transferring radium on clocks. No tipping of brush in her mouth. She remembers no luminescence of hair or clothing. She does remember occasional luminescent spots on the backs of her hands and on her arms. No further contact with radioactive substances since 1931. Dental History: has had trouble with her teeth from her early teens on, with gradual loss of individual teeth over the years to the present time when she has seven remaining upper teeth. There was no difficulty with healing of the sockets after extraction.

Physical Examination: a well-developed and nourished woman, weight 136 lbs., height 65", BP 140/78, pulse 86 and regular. Eyes: pupils react normally and equally to light and accommodation. Extraocular movements normal. Ears: negative. Nose and Throat: normal. Seven remaining upper teeth only. These are in good repair. Gums normal. Neck: no cervical adenopathy. Thyroid not enlarged. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: soft and relaxed. Liver and spleen not felt. Pelvic and Rectal: not done. Extremities: bilateral hallux valgus, otherwise normal. Romberg negative. Reflexes: equal and active. Skin: normal.

Lab. Findings: Urinalysis: sp. gr. 1.007, albumin neg., sugar neg., 10-12 epith/HPF. Hematology: wbc 8100, differential P51, L47, M2, rbc normocytic, corr. sed. rate 6 mm/hr., hematocrit 46 percent. Blood chemistries: alk. phos. 3.4 units, BUN 13.8 mg percent, sugar 92 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.8, alb 4.8, TG 2.0, $\alpha 1$ 0.3, $\alpha 2$ 0.5, β 0.6, γ 0.6

X-ray Findings: skeletal series shows no evidence of radium poisoning. One

or two cyst-like rarefactions in the right femoral neck and upper shaft are within the limits of normal variation. Heart and lungs are normal in appearance. The sella is slightly demineralized. This is not an uncommon finding in postmenopausal women and it is probably of no significance. Examination of the teeth shows filling defects in the right upper anterior incisors and the left canine which could be caries or nonopaque fillings. There is perialveolar absorption, otherwise no abnormalities are seen.

(01-201) Born 29 June 1911. Present Health: good at the present time and has been in recent years, except for mild hypertension for which she has been taking medication during the past one or two months.
Systems Review. Eyes: no history of any abnormalities. Ears, Nose, and Throat: normal. No history of any swollen glands in the neck or elsewhere. CR: negative. GI: normal. Bowels regular without laxatives. No history of any blood in the stools. GU: negative. Catamenia: menarche at age 12-1/2. Periods regular to the present time. Some hot flashes in recent months. NM: negative. Skin: no abnormalities. Habits: appetite somewhat too good. Recent slight weight gain. Sleeps soundly at night. Does not smoke. No alcohol consumed. Gets plenty of exercise around her home. Past History: usual childhood diseases but no specific history of diphtheria, rheumatic fever, scarlet fever. No history of any allergy or epilepsy. One moderately severe nervous breakdown at the age of 28 for a period of 6-9 months. Uneventful recovery. Appendectomy at age 26. Tonsillectomy in childhood. Fracture of one leg in childhood. Family History: father aged 75, living and well; mother aged 73, living and well. Nine siblings living and well. No family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental illness. Marital History: married 31 years to the present time. Husband aged 51, living and well. Four children living and well, ages 21, 20, 18, and 11. Oldest child is married and has one child. Radiation Exposure: painted luminous watch dials for a period of about 14 months (22 October 1925 - 11 October 1926 and 10 January 1927 - 17 February 1927), starting at age 14. She pointed the brush in the mouth regularly. She does not remember any luminescence of hair or clothing. Dental History: has lost approximately 10 teeth, one at a time, over the years. There was no difficulty in healing of the sockets after extraction.
Physical Examination: a well-developed and slightly overweight woman of 48 weighing 167 lbs., height 61", BP 130/82, pulse 84 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat:

normal. Remaining teeth in good repair. Neck: no cervical adenopathy. Thyroid not enlarged. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: slightly obese. Liver and spleen not felt. Pelvic and Rectal: not done. Extremities: normal. Reflexes: equal and active. Romberg negative. Skin: no abnormalities.
Lab. Findings: Urinalysis: sp. gr. 1.009, albumin neg., sugar neg., 4-6 epith/HPF, occ. rbc/HPF. Hematology: wbc 8100, differential P67, L27, E2, M4, rbc normocytic, corr. sed. rate 8 mm/hr., hematocrit 41 percent. Blood chemistries: alk. phos. 5.2 units, BUN 14 mg percent, sugar 105 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.6, alb 4.6, TG 2.0, $\alpha 1$ 0.4, $\alpha 2$ 0.3, β 0.7, γ 0.6.
X-ray Findings: skeletal series shows no evidence of radium poisoning. The skeleton is normal in appearance. There is minimal calcareous bursitis at the right greater tuberosity and the left greater trochanter. Heart and lungs appear normal. Examination of the remaining teeth showsno evidence of abnormalities other than perialveolar absorption. Bony structures are normal in appearance.

(01-202) Born 19 July 1925. Present Health: considers his health only fair at the present time. He is being investigated for aquestion of a disc injury in the lower back which causes numbness of the left thigh. He has had symptoms of this sort off and on for the past four years. He was hospitalized for a period of several weeks in March 1959 for further study of this complaint. Other symptoms are mostly referable to a head injury which he received on an oil tanker in 1943. Following this injury he had gradual loss of vision of the left eye during the next 1-1/2 years. Following this, he developed headaches and fainting spells during the next four years; this culminated in hospitalization and extensive studies of his nervous system. In the course of these investigations, myelograms, angiograms, and ventriculograms were done. In the course of these tests, he was given injections of Thorotrast. He states that no definite pathology was found. He was able to return to work in 1948 after the symptoms of headache and fainting spells had subsided with another year's rest at home.
Systems Review. Eyes: right eye normal; left eye shows less than 20/100 vision since the accident noted above. Ears, Nose, and Throat: normal. Neck: normal, no history of any swollen glands in the neck or elsewhere. CR: negative. GI: normal. Bowels regular without laxatives, no history

of any blood in the stools. GU: negative, except for sterility during six years of marriage. NM: see present illness. At the present time he has very few headaches and no more of the fainting attacks. He still has, to a rather marked degree, the paresthesia of the left thigh. No skin abnormalities. Habits: appetite good. No weight changes in recent years. Sleeps soundly at night. Smokes 10-20 cigarettes daily. Alcohol consumption minimal. Gets plenty of exercise at work and around his home. Past History: usual childhood diseases; he also had scarlet fever. No history of diphtheria, rheumatic fever, allergy, epilepsy, or mental illness. Operations: in addition to the extensive neurological studies including a craniotomy for the ventriculograms, he had an appendectomy in 1947. He also had an injury to the left foot at 4 years of age. No other fractures, hospitalizations, or accidents. Family History: father 59, living and well; mother 56, living and well. Seven siblings, living and well. One brother died of leukemia at age 20. Marital History: married six years, wife 25, living and well. No children, no pregnancies. This is of concern to the patient and he is anxious to have a complete investigation of this difficulty. Dental History: he had lost only two permanent teeth to date, but he is greatly concerned because of the recent increase in dental caries that he has had. Radiation Exposure: consists solely of the injection of Thorotrast for the procedures outlined above. This occurred presumably in 1949. No exposure since that time.

Physical Examination: a robust, well-developed and nourished man, weight 176 lbs., height 69", BP 112/68, pulse 80 and regular. Eyes: right eye apparently normal; left eye shows sluggishly reacting irregular pupil; extraocular movements of left eye slightly erratic, eye tends to wander when the right eye focuses on a fixed point. No definite nystagmus. Face: well-healed scar, left upper lip, Ears: negative. Nose and Throat: normal. Teeth: seem to be in moderately good state of repair. Neck: no cervical adenopathy, thyroid not palpable. Heart and Lungs: normal to auscultation and percussion. Abdomen: soft and relaxed. Well-healed appendectomy scar, right lower quadrant. Inguinal rings normal. Both testes in scrotum, small and firm. Rectal: prostate very small, scarcely palpable; no other pathology. Extremities: the fingernails are small, with evidence of nail-biting. Reflexes: slight diminution of knee jerk on left; other superficial reflexes normal. Romberg negative.

Lab. Findings: Urinalysis: sp. gr. 1.025, albumin neg., sugar neg., 0-1 rbc/HPF, 0-1 wbc/HPF. Hematology: wbc 8100, differential P64, L36, rbc

normocytic, corr. sed. rate 16 mm/hr., hematocrit 42 percent. Blood chemistries: alk. phos. 3.0 units, BUN 22.6 mg percent, sugar 126 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.8, alb 4.13, TG 2.67, α1 0.25, α2 0.65, β 0.67, γ 1.10. Thymol Turbidity - Cephalin Flocculation: TT 1.0 units, CF 24 hrs. neg., 48 hrs. 1 plus.
X-ray Findings: skeletal series shows the following abnormalities: there are burr holes in the skull as a result of the previous craniotomy. There is marked sclerosis of the left antrum in the form of thickened maxillary bone laterally. There is some thickening of the mucoperiosteum in the right antrum. The other sinuses are normal. The peripheral bones show no evidence of radium. There is calcification in the medial collateral ligament of the left knee, most likely due to an old injury. The heart and lungs are normal in appearance. The spleen is filled with speckled densities. From the history it can be assumed to be deposits of thorium in the reticuloendothelioma system of the spleen. The liver is not abnormally dense. Numerous unusual densities are seen superimposed on the upper mid-abdomen. This could be something in the stomach or pancreas. Conclusion: no evidence of radiation osteitis. Local changes in the sinsuses are probably on the basis of old infection. Abnormalities in the spleen are due to thorium.

(01-203) Born 22 September 1908. Present Health: only fair. She has been troubled with asthma and obesity for the past 15 years or more. Five years ago she lost 40 lbs. with dieting, but regained all of them after two years. She is also troubled intermittently with varicose ulcers of both lower legs.
Systems Review: no abnormalities or difficulties with the eyes, ears, nose, or throat, except for moderate trouble with hay fever at certain times of the vear. No history of any swollen glands in the neck or elsewhere. CR: some cough with asthma only. No history of any chest pains. GI: some feeling of distention from gas, no nausea or vomiting, bowels regular without laxatives. No history of any blood in the stools or melena. GU: some urinary frequency, otherwise normal. Catamenia: menarche at age 12, periods regular until two years ago at the age of 49. No flowing since that time. NM: occasional severe headaches associated with nausea and vomiting diagnosed as migraine attacks. These are infrequent at the present time. Skin: some rashes of legs. She was told this was due to an allergy. Skin tests for allergy have been inconclusive. Habits: appetite too good.

See history above. Weight gain in recent years. Sleeps soundly at night. smokes 5-10 cigarettes daily. Takes no alcohol. Past History: usual childhood diseases and scarlet fever. No history of any diphtheria or rheumatic fever. Allergy manifested by varying degrees of asthma and some hay fever. No history of any epilepsy or mental illness. Operations: right mastectomy in 1952, seven years ago, because of a bloody discharge from the nipple of the breast. She was told that this was caused by cancer. There was also a simple excision of a nodule, presumably benign, from the other breast at the same time. She had a ligation of the left leg for varicose veins and varicose ulcers approximately five or six years ago. She had pneumonia at the age of 18. No other hospitalizations, fractures, or accident. Family History: father died at 94, cause not determined. Mother died at 55 of diabetes. One sister died at 14 of heart disease. No other familial history of diabetes. No history of any cancer, tuberculosis, allergy, epilepsy, or mental illness. Marital History: patient has never married. Dental History: gradually lost all of her teeth, a few at a time. She had all of the upper teeth extracted by the age of 38. The remaining lower teeth were all extracted by the time she was 45 years of age. There was no trouble with healing of the sockets after extraction. Radiation Exposure: for a period of a week, 2 February 1923 to 7 February 1923, this patient worked as a luminous dial painter at the age of 14. She disliked pointing the brush in the mouth, so left this type of employment at the end of the week. No further contact with radium or radioactive substances since that time. She does not remember any luminescence of the hair or clothing during her period of employment as a dial painter.
Physical Examination: a well-developed and obese woman of 51, weight 177 lbs., height 60", BP 140/90, pulse 84 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Teeth all removed. Gums in good condition. Neck: no cervical adenopathy or thyroid enlargement. Heart: normal to auscultation. Sounds regular, no murmurs heard. Lungs: many asthmatic rhonchi throughout both lungs. Breasts: right breast removed by operation, scar well healed. Left breast normal. Abdomen: obese, no masses felt. Pelvic and Rectal: not done. Extremities: scars of both lower legs from previous varicose ulcers. Moderate varicosities of both legs. Reflexes: hyperactive.
Lab. Findings: Urinalysis: sp. gr. 1.017, albumin neg., sugar neg., 25-30 epith/HPF, 1-2 wbc/HPF, occ rbc/HPF. Hematology: wbc 9100, differential P54, L43, E2, M1, rbc normocytic, corr. sed. rate 15 mm/hr., hematocrit

44 percent. Blood chemistries: alk. phos. 4.7 units, BUN 17 mg percent, sugar 99 mg percent, Hinton positive. Electrophoresis (grams percent): TP 6.4, alb 4.2, TG 1.2, α1 0.3, α2 0.5, β 0.7, γ 0.7.
X-ray Findings: skeletal series shows the following abnormalities: There are minimal degenerative changes about the right elbow. There are deposits of heavy metal in the buttocks on either side. There are some calcific shadows on the buttocks on both sides due to previous intramuscular injections of a nonmetallic nature. There are degenerative changes of moderately advanced degree in the dorsal spine. No evidence of radiation osteitis is seen. The patient is edentulous.

(01-204) Born 27 April 1901. Present Health: patient considers herself to be in quite good health at the present time.
Systems Review. Head: gets occasional headaches. Notes for the past several months that if she jumps out of bed quickly in the morning will feel dizzy and tend to black out. This can be stopped by easing slowly out of bed. Eyes: wears glasses at all times. Has no diplopia or infection. Ears: good hearing, no infections, no tinnitus. Nose: had epistaxis as child; feels that her sense of smell is adequate. Mouth: eighteen years ago she says she had a small growth burned off of her vocal cords. Now occasionally notes that cold liquids seem to stick in her throat, and for the past 18 years will get a transient vague choking sensation at times. Neck: no known goiter, prefers hot weather to cold. Twenty-five years ago had radiation epilation done to the skin of her lower jaw. This was followed by scarring of her jaw and a mass under her chin which she says will change in size and consistency. It has apparently been present for at least 20 years. Breasts: negative. CR: no ankle edema, no dyspnea on exertion, sleeps on one pillow; gets a rare substernal dull pain which radiates to the neck and does not seem to be associated with exertion, diet, etc. No pneumonia, no hemoptysis; was told a few years ago that she had a blood pressure elevation to 225, does not use a salt shaker, carries nitroglycerine but never uses them. She was told to take Raudixon for high blood pressure but has discontinued them on her own. GI: good appetite, no food dyscrasias, is trying to lose a little weight. No history of jaundice; no abdominal discomfort or gas. About 15 years ago had an episode of colitis which lasted several months, but is now completely gone. Bowels move once a day, no laxatives, no blood in the stools. GU: no known infections, no nocturia, no dysuria. Catamenia: menarche at age 15,

menopause at age 55 or 56, note D and C mentioned below. Extremities: for something over a year she has had morning stiffness and pains in the fingers of both of her hands which she has been told were arthritic. Also has had arthritic-type pains in her spine. For these pains she takes aspirin; however, two months ago went on a trial course of 20 cortisone tablets, and they caused complete subsidence of the pain. Neurological: negative. Habits: about 15 cigarettes per day, no alcohol, phenobarbital for sedation about one time per month. Sleeps five to seven hours per night. Past History: operations - D and C in 1958 done for diagnostic purposes following an episode of vaginal staining; the results of this were apparently normal. Serious illnesses: none. Allergies: none. Family History: father died at the age of 61 of heart trouble; mother died at the age of 80 of heart failure. A brother died at age 59 of a heart condition; two brothers, still living, have had coronaries. One brother is in good health, is a physician. Marital History: is married, has two sons ages 30 and 25, who are living and well. The younger one has numerous allergies. Dental History: has her own teeth which she considers to be in good condition. She sees her dentist about once a year. Has no dentures. Radiation Exposure: she painted dials sometime during World War I when she was 16 or 17. She worked there somewhere between three and six months. She does not recall licking the brush; however, she did lick the tip of her fingers and then point the brush on this. Does not recall glowing in the dark. Physical Examination: height 59.5", weight 168 lbs., BP 226/90, pulse 68. Patient is a short, obese, active, alert, 58-year-old woman who looks healthy and in no distress. Head: eyes - pupils equal, react to light and accommodation. No arcus. Fundi show early nicking and tortuosity. No hemorrhage or exudates. Ears: negative. Nose: negative. Mouth: tongue well papillated. Pharynx normal. Neck: small thyroid, carotids pulsating bilaterally. There is about a 1-inch irregular midline movable mass under her mandible which is not tender. Breasts: no masses or tenderness. Chest: good resonance, normal breath sounds, no rales. Heart: not enlarged, normal sinus rhythm, good tones, A2 louder than P2. Abdomen: obese, no scars, no organs, masses, or tenderness, good femoral pulsations. Pelvic and Rectal: not done. Extremities: rheumatoid-like spindling of fingers, good pedal pulsations, 2-plus pitting edema of the ankles, few slight superficial varicosities of the lower legs. Skin: mottled scarring of the skin under the mandible. Neurological: within normal limits. Diagnoses: obesity, question of radiation fibrosis of the submandibular area, arterio-

sclerotic hypertensive cardiovascular disease.
Lab. Findings: Urinalysis: sp. gr. 1.026, albumin neg., sugar neg., 3-5 epith/HPF, occ wbc/HPF, 1-2 rbc/HPF. Hematology: wbc 7600, differential P58, L36, E6, rbc normocytic, corr. sed. rate 29 mm/hr., hematocrit 45 percent. Blood chemistries: alk. phos. 2.7 units, BUN 16.5 mg percent, sugar 95 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.9, alb 4.37, TG 2.53, $\alpha 1$ 0.28, $\alpha 2$ 0.53, β 0.80, γ 0.92.
X-ray Findings: skeletal series which includes films of the teeth shows no evidence of radium poisoning. There are some minor degenerative changes about various joints consistent with the patient's age. The heart and lungs are normal.

(01-205) Born 21 November 1921. Present Health: patient brings up the following three points: 1. he has a known pilonidal cyst since 1942 which tends to act up every so often. One month ago it was draining and required lancing. 2. in World War II he had pneumonia; since then has had a morning cough. Has had several chest x-rays, all of which were probably normal. 3. his wife worries about his bowel habits. He says he spends long periods of time in the toilet, mainly because he finds this is an excellent refuge. Periodically, but infrequently, he will have 24 hours which start with abdominal cramps, go on to one loose bowel movement, and then he becomes constipated for a day or two.
Systems Review: has occasional morning headaches. No fits or epilepsy, etc. Eyes: myopic and astigmatic, no diplopia. Ears: hearing good, no infections, no tinnitus. Nose: good sense of smell, no epistaxis. On occasion will have sinus trouble. Throat: no dysphagia; in the past four years, about one time a year, will get swelling of his "Adam's apple". This usually starts with a cold which goes on to a sticking feeling in his throat, then his "Adam's apple" begins feeling tender and he may have a little pain on swallowing. He has seen doctors for this, some of whom feel it is allergic, others infective. Neck: no known goiter, but several years ago he had a BMR of -11 and was put on white pills for his thyroid which he discontinued himself. CR: note below history of pneumonia and bronchitis. No ankle edema, no dyspnea on exertion, no chest pain on exertion but gets random pains in his lower rib cage on occasions. Two years ago he was told he had a faint insignificant heart murmur. Also was told that he had high blood pressure; he thinks it was in the 140-160 range. He uses a salt shaker on his food before tasting it and is probably a heavy salt user.

GI: his weight in 1942 was 145 lbs., in 1945 it was 168 lbs., for the past three years it has averaged around 185-190 lbs. He has a good appetite. Gets diarrhea from beer; believes that he has a nervous stomach. In his teens had many gas pains, never had yellow jaundice. Bowels move two to three times a day. Will take as a laxative, on occasions, citrate of magnesia. GU: no nocturia or dysuria. Denies veneral disease. Extremities: has weak wrists and ankles, but has not had rheumatism or arthritis; has a trick right knee, no varicose veins, no intermittent claudication. Has a restless right leg in bed at night. Skin: occasional acne over his trunk. Habits: smokes 30 cigarettes a day, but says he does not inhale. Occasionally will smoke three to four pipes a day. Moderate alcohol intake. No medications. Has usually about six hours sleep a night interrupted by his children. Past History: operations - appendectomy at age 9 or 10, tonsillectomy at age 5 or 6, lanced pilonidal cyst in June 1959. Serious illnesses: pneumonia in September 1942 while in the U. S. Army, probably bacterial in etiology; pneumonia in August 1952 of unknown etiology; bronchitis since childhood; an episode of bacillary dysentery in the U.S. Army while in the southwest part of the U. S. Allergies: develops skin rash from leather wrist-watch band, also when given sulfonamides. In the Army developed a macular rash over his body. Family History: father died at age of 68; he had had trigeminal neuralgia and developed some type of paralysis postoperatively. Mother is living, age 69, has high blood pressure and arthritis, and migraine headaches. She developed a pain-like trigeminal neuralgia which her doctor expects might be nerves. Patient has no siblings. There is no tuberculosis or diabetes in the family; however, his mother's sister and his mother's three brothers all wear hearing aids. This is possibly an otosclerosis. Marital History: is married and has three children, ages 3, 2, and 1 month, all of whom are in good health. One child died at the age of 2 months because of a congenital heart. This turned out to be a complete transposition of the great vessels with an interventricular septum defect. Dental History: has all of his own teeth, no plates. Wore a bridge as a child. Has had no trouble with his teeth for the past ten years and sees his dentist about every eight months. Radiation Exposure: worked from 1951 to 1952 (about 1 year) with radium and polonium. Breath radon samples and urine tests done at that time showed he had one-third of tolerance dose. Worked from 1952 to 1955 handling fission products with low levels of activity. He wore a film badge which was always within normal limits. Since 1955 he has worked handling fission

products with high levels of radiation, runs a "hot" lab.
Physical Examination: height 67-3/4", weight 188.5 lbs., BP 175/102 in the right arm, while recumbent pulse is 92. Patient is a well-developed, moderately obese, healthy-looking, very talkative, 37-year-old man who wears a Beatnik beard. Head: eyes - pupils equal, react to light and accommodation, extraocular movements normal, fundi within normal limits. Patient is myopic. Ears: drums intact, hearing good. Nose: no abnormalities. Mouth: teeth present in good state of repair. Throat: benign, well-papillated tongue. Neck: no enlarged nodes. Carotids both pulsating. Small thyroid. Lymphatics: no enlarged nodes felt anywhere. Lungs: resonant to percussion, good breath sounds, no rales. Heart: not enlarged, tones clear but somewhat distant, no murmurs, A2 greater than P2. Abdomen: obese, not distended, puckered RLQ appendectomy scar, no organs, masses, or tenderness, no CVA tenderness, good femoral pulsations. Genitalia: testes both down, no masses, no inguinal hernias felt. Rectal: has several small indentations of the pilonidal region, no draining sinus, no external hemorrhoids noted. Extremities: good peripheral pulsations, no edema, no joint pathology, no varicose veins. Neurological: within normal limits, save that he has some hyperesthesia of the skin in the region of the appendectomy scar and has no left cremasteric reflex. Cremaster reflex on the right is normal. Skin: negative. Diagnoses: hypertension of unknown etiology, obesity, myopia, and stammering.
Lab. Findings: Urinalysis: sp. gr. 1.010, albumin, neg., sugar neg., amorphous phosphates. Hematology: wbc 9200, differential P59, L39, E1, M1, rbc normocytic, corr. sed. rate 23 mm/hr., hematocrit 48 percent. Blood chemistries: alk. phos. 5.3 units, BUN 17.5 mg percent, sugar 96 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.6, alb 4.88, TG 2.72, $\alpha 1$ 0.32, $\alpha 2$ 0.60, β 0.83, γ 0.97.
X-ray Findings: skeletal series shows no evidence of radium poisoning. Incidental findings are: a widening of the base of the proximal phalanx of the left middle toe most likely due to a cyst-like structure like a benign cyst or possible enchondroma. Conceivably but less likely the appearance of the toes is due to an old healed fracture; slight scoliosis of the dorsal spine in comparison to the right. Single dental film of the upper left molar area fails to show any paradental disease. The alveolar process as far as it is visible appears normal.

(01-206) Born 4 September 1896. Present Health: good at the present time and has been in recent years. He has no particular complaints at the present time.
Systems Review: Eyes, Ears, Nose, Throat: no difficulty. No history of any swollen glands in the neck or elsewhere. CR: negative. GI: no difficulties at the present time, but a few years ago he was under the impression that he had a peptic ulcer. Further investigation showed that he had no ulcer but did have some spasm of the colon. This responded to Gerusil therapy, diet, and some other type of medication. Bowels are regular now without laxatives. No history of any blood in the stools or melena. GU: negative. NM: patient was hospitalized for a period of three weeks last year for a so-called "frozen" shoulder on the left side. This was treated with manipulation and physiotherapy. He has had no trouble since that time. Skin: no abnormalities. Habits: appetite too good, if anything. Keeps his weight with strict diet. Sleeps soundly at night. Has not smoked since 1952. Alcohol consumption averages 1-2 drinks per day. His exercise consists mostly of walking. Past History: usual childhood diseases but no history of any scarlet fever, rheumatic fever, diphtheria, allergy, or mental illness. Only hospitalization was for treatment of shoulder joint last year and investigation of his g.i. tract two years ago (see above). No history of any fractures, accidents, or injuries. Family History: father died at 70 of heart disease; mother died at 70 of cancer. Two sisters living and well. No other history of cancer in the family. No history of diabetes, tuberculosis, allergy, epilepsy, or mental illness. Marital History: married from 1920 to 1952 when his wife died at the age of 54 of Hodgkin's disease. He married for the second time in 1954 to the present. One child, age 32, from first marriage living and well. This child is also married and has three children. There were two other children born of his first marriage ; the first was a stillborn, the other died a few hours after being born, cause undetermined. Dental History: has had some trouble with his teeth and at the present time has lost approximately one-half of his permanent teeth. When he lost any by extraction there was no difficulty with healing afterwards. Radiation Exposure: in 1918 for a period of four months he was employed working on the purification of radium by fractional crystallization. At this time the work was done without any regard for safety of the workers. He left to enter World War I. No further contact with the radium industry after that time.

Physical Examination: a robust, healthy-appearing man of 63, weight 199 lbs., height 71", BP 138/84, pulse 78 and regular. Eyes: pupils react only slightly to light and are very small but equal. Ears: drums not visualized because of cerumen. Nose and Throat: normal. Remaining teeth in good state of repair. No cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Abdomen: soft and relaxed. No masses felt. Inguinal rings show some enlargement on the right, but no definite hernia. Genitalia: normal. Rectal: 1-plus enlargement of the prostate. Reflexes: equal and active. Romberg negative. Extremities: normal.
Lab. Findings: Urinalysis: sp. gr. 1.021, albumin neg., sugar neg., 3-5 rbc/HPF. Hematology: wbc 6100, differential P46, L48, E4, M2, rbc normocytic, corr. sed. rate 12 mm/hr., hematocrit 50 percent. Blood chemistries: alk. phos. 7.2 units, BUN 20 mg percent, sugar 89 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.2, alb 4.8, TG 2.4, $\alpha 1$ 0.18, $\alpha 2$ 0.49, β 0.76, γ 0.97.
X-ray Findings: skeletal series including the teeth shows no evidence of radiation osteitis. There are some minor degenerative changes in the extremities consistent with the patient's age. No other abnormalities are seen.

(01-207) Born 19 March 1909. Present Health: only fair and she has had varying degrees of indigestion for the past 20 or more years. Many x-rays of her intestinal tract have been taken.
Systems Review. Eyes: wears glasses for reading only. Ears: has had many types of therapy for a chronic external otitis, bilateral, for the past 10 or more years. She has had some x-ray treatment of these external canals. She is now troubled with some scaling and itching of the canals, left and right. Nose and Throat: negative. No history of any swollen glands in the neck or elsewhere. CR: negative. GI: has had indigestion, usually in the form of heartburn for a long time. For the past six months she has been troubled with frequent episodes of nausea, vomiting, and abdominal pain. Occasionally these attacks are associated with severe headaches. Lately they have been relieved only by hyperdermic injections. X-rays have shown a question of an ulcer of the stomach and gastritis in the past year. X-rays of the gallbladder showed some inflammation. She has been on a variety of medications from March to July of this year. She is occasionally troubled with diarrhea during her bouts of indigestion.

There is no known history of any blood or melena in the stools. GU: negative. Catamenia: menarche at age 13, periods regular until age 45 when they stopped completely. She has had some trouble with hot flashes during the past few years. NM: some mild arthritis of the hands and feet. No great limitation of motion. Skin: no abnormalities. Habits: appetite too good, if anything. No weight change in recent years. Sleeps fairly well. Does not smoke. Alcohol taken only occasionally. She gets a great deal of exercise around her home. Past History: usual childhood diseases. No specific history of scarlet fever, rheumatic fever, diphtheria, epilepsy, or mental disorders. Operations: she had one caesarian section at age 32, hemorrhoidectomy a few years later. She had operative repair of the upper jaw following a tooth extraction at age 35. Has had frequent operations for ingrown toenails. She fractured her right tibia at the age of 15. No other hospitalizations. Family History: father died at 42 of pneumonia; mother died at 65 of cancer and shock. Four siblings living and well. Four siblings died, one of cancer of the mouth, one of cancer of the stomach, one of cancer of the rectum, and one of heart disease. No family history of tuberculosis or diabetes. No family history of any allergy, epilepsy, or mental disorders. Marital History: married 22 years to the present time; husband age 57, living and well. One child age 18, living and well. No other pregnancies. Dental History: she has gradually lost all but eight teeth over the years. Dental difficulties began during her pregnancy at age 31. She has lost no teeth since that time. She has had one follow-up operation a year later, noted above, at age 35. Radiation Exposure: in 1927 at the age of 18 she was employed painting luminous watch dials, from 2 March to 4 May. She denies any tipping of the brush in her mouth. She remembers no luminescence of the hair or clothing. Physical Examination: well-developed and nourished woman, weight 147 lbs., height 62", BP 150/90, pulse 86 and regular. Eyes: normal, extraocular movements normal, pupils react normally to light and accommodation. Ears: mild scaling of both external auditory canals. Nose: some deviation of the septum to the left. Lower front remaining teeth in good repair. Wears full upper plate. Neck: no cervical adenopathy or thyroid enlargement. Heart: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: some tenderness in the right upper quadrant. There is a midline scar in the lower abdomen, site of old caesarian section. Pelvic and Rectal: not done. Extremities: some superficial varicosities. Reflexes: equal and active.

Lab. Findings: Urinalysis: sp. gr. 1.016, albumin neg., sugar neg., 4-6 epith/HPF, 2-4 wbc/HPF, 1-3 rbc/HPF. Hematology: wbc 5800, differential P66, L28, E2, M4, rbc slight hypochromia, corr. sed. rate 19 mm/hr., hematocrit 37 percent. Blood chemistries: alk. phos. 3.6 units, BUN 15.2 mg percent, sugar 85 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.9, alb 4.5, TG 2.4, $\alpha 1$ 0.22, $\alpha 2$ 0.43, β 0.82, γ 0.94. X-ray Findings; skeletal series shows degenerative changes of a minor degree in the first metatarsal-phalangeal joints, and about the distal phalangeal joints of the fingers. There is some calcification on the lower margin of the left clavicle due to an old injury to the coracoclavicular ligament. Otherwise the skeleton is normal in appearance, and the heart and lungs show no abnormalities. There is only a single lateral film of the skull and there does appear to be some calcification inside the pituitary gland. This would need to be confirmed by lateral stereo films centered over the pituitary; however, there is doubt if it is of any clinical significance. Films of the remaining teeth and of the alveolar ridges show no evidence of radiation necrosis.

(01-208) Born 21 March 1901. Present Health: generally good and has been in recent years. He is contemplating an operation for varicose veins in the next few months. Otherwise he has no complaints.
Systems Review. Eyes: wears glasses continuously, otherwise no difficulty. Ears, Nose, and Throat: normal except for a deviated septum. He used to be troubled with chronic sore throats but this has cleared up since he stopped smoking. No history of any swollen glands in the neck or elsewhere. CR: occasional dyspnea on exertion only. GI: normal except for some tendency to gas and mild indigestion. Bowels regular without blood. GU: negative. NM: some joint pains in the left elbow and wrist. He had a bilateral ligation for varicose veins 18 years ago. Veins have now recurred and he is contemplating another operation this fall. He has some difficulty with leg cramps at night. Skin: some dermatitis of both wrists which has been present off and on for the past 2 years. Habits: appetite good, there has been a slight weight gain of about 15 lbs. since he stopped smoking 2 years ago. Sleeps soundly at night. Alcohol consumption averages 1-2 drinks per week. He gets no regular exercise. Past History: had the usual childhood diseases and also had typhoid fever. He does not remember any history of scarlet fever, diphtheria, allergy, epilepsy, or mental disorder. Operations consist of ligation of varicose veins as noted above. No history

of any fractures, accidents, or injuries. Family History: father and mother were killed or died in Russia at the time of the revolution in 1917. Nothing is known about his siblings, or the presence or absence of diseases such as cancer, diabetes, tuberculosis. Marital History: married 27 years to the present time. Wife, 52, living and well. There are two children, aged 25 and 24, both living and well. Neither of them are married. Dental History: he had lost all of his teeth by the time he was 45. This was a gradual process. There was no difficulty with the healing of the sockets after extraction. Radiation Exposure: approximately 25 years ago he worked for a period of 1.5 years engaged in the refining of radium from its natural ores. Since 1942 he has been in charge of the radium and x-ray laboratory. He feels that in the course of his work he has processed approximately 20 grams of radium and radium products. He has kept a record of his blood count for many years and the wbc ranged from 4000 to 7000, no higher and no lower. One year exposure to cesium in 1958.

Physical Examination: a well-developed and nourished, vigorous-appearing man of 58, weight 188 lbs., height 68", BP 150/102, pulse 88 and regular. Eyes: pupils and extraocular movements normal. Ears: not visualized because of wax. Nose: deviation of the septum. Throat: normal. Teeth all absent. Wears full upper and lower dentures. Neck: no cervical adenopathy. Thyroid not palpable. Heart and Lungs: normal to auscultation and percussion. Abdomen: soft and relaxed. No masses felt. Inguinal rings normal. Rectal and Prostate: negative. Extremities: bilateral varicose veins of the lower legs, bilaterally although more pronounced on the left than on the right. There is a small exostosis of the left tibia. He has a small ganglion on the right wrist. There is a superficial, punctate dermatitis of both wrists. Tips of fingers of both hands show so-called radiation burns characterized by multiple scaling atrophic areas 2 to 5 mm in diameter. Reflexes: equal and active. Romberg negative.

Lab. Findings: Urinalysis: not done. Hematology: wbc 4900, differential P52, L43, E3, M2, rbc normocytic, hematocrit 45 percent. Blood chemistries: alk. phos. 3.8 units, BUN 20 mg percent, sugar 101 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.3, alb 5.08, TG 2.22, $\alpha 1$ 0.18, $\alpha 2$ 0.45, β 0.61, γ 0.98.

X-ray Findings: skeletal series shows no evidence of radiation osteitis. There are some degenerative changes about the first metatarsal phalangeal joints of the feet. The heart is slightly enlarged having transverse diameter of 16 cm compared to a thoracic diameter of 32 cm. Its configuration suggests

that the left ventricle accounts for the enlargement. No other abnormalities are seen. Dental films show the patient to be edentulous. No evidence of radium necrosis is seen.

(01-209) Born 7 November 1908. Present Health: good health at the present time except for some elevation of her blood pressure for which she has been taking medication in recent months. She has no complaints at the present time.
Systems Review. Eyes: normal. Ears: intermittent difficulty for the past 5 years with otitis externa of both ears. Nose: has had sinuses drained on at least one occasion. She is subject to rather severe sore throats and last year had to have one peritonsillar abscess opened surgically. No history of any swollen glands in the neck or elsewhere. CR: some palpitation in recent years. This has been relieved by the medication she has taken for high blood pressure; otherwise no c.r. complaints. GI: occasional attacks of indigestion precipitated by particular foods. No nausea or vomiting. Bowels regular, no history of any blood in the stools or melena. She has had trouble from time to time with a small anal fissure. GU: negative. Catamenia: menarche at age 11, periods regular until age 46, some hot flashes at the present time. NM: some arthritis of the knees. This was treated within the last year or so with cortisone injections and physiotherapy. She made a nearly complete and otherwise uneventful recovery from this illness. Skin: no abnormalities. Habits: appetite too good. She has been able to reduce her weight by 12 lbs. with very strict dieting during the past year. She sleeps poorly at night due to her working hours. Occasionally takes sleeping pills for insomnia. She smokes only rarely. Alcohol consumption nil. Gets plenty of exercise at her work. Past History: she remembers a few childhood diseases. No specific history of scarlet fever, rheumatic fever, or diphtheria. No history of any allergy, epilepsy, or mental illness. Operations: for varicose veins 1 year ago; also one D and C 5 years ago. She fractured right leg in 3 places in 1939 in an automobile accident. No other accidents, fractures, or injuries. Family History: father died at 49 in a drowning accident; mother, aged 71, living and well. One brother died at 46 of heart disease. One sister, aged 36, living but subject to attacks of mental illness. No history of any cancer, diabetes, tuberculosis, allergy, or epilepsy in the family. Marital History: married for the first time at age 20 until age 34 when husband was killed in an automobile accident.

Second marriage from age 37 to age 40; husband died of heart disease. No children or pregnancies with either marriage. Dental History: she began to have severe trouble with her teeth when she was 21 or 22 years old. This was about two years after she stopped painting watch dials. They all seemed to go bad at one time with pyorrhea and the breaking off of many teeth. She remembers some difficulty with healing of the sockets after extraction, but once all of the teeth were removed there was no further difficulty of this sort. Radiation Exposure: patient was employed at painting luminous watch dials at the age of 17 for a period covering 13 September 1926 - 8 November 1926 and 13 December 1926 - 9 February 1927. She pointed the brush regularly in her mouth for the entire period of her employment. She remembers marked luminescence of hair and clothing when she went home at night on many occasions. Following termination of her employment, she had no other contact with the radium industry. She remembers, however, being tested when she was 21 or 22 years of age.

Physical Examination: a well-developed and markedly obese woman, aged 51, weight 201 lbs., height 60", BP 220/110, pulse 90 and regular. Eyes: pupils react normally and equally to light and accommodation, extraocular movements normal. Ears: negative at this time. Nose and Throat: normal. Wears full upper and lower dentures. Neck: no cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: obese. Liver and spleen not felt. Pelvic and Rectal: not done. Reflexes: equal and active. Extremities: legs show scars from operations for varicose veins, otherwise normal.

Lab. Findings: Urinalysis: sp. gr. 1.020, albumin neg., sugar neg., 4-6 epith/HPF, 2-3 wbc/HPF, 1-2 rbc/HPF, little bacteria. Hematology: wbc 10,600, differential P60, L38, E1,M1, rbc normocytic, corr. sed. rate 32 mm/hr., hematocrit 44 percent. Blood chemistries: alk. phos. 5.4 units, BUN 22 mg percent, sugar 129 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.0, alb 4.32, TG 2.68, $\alpha 1$ 0.24, $\alpha 2$ 0.53, β 0.74, γ 1.17.

X-ray Findings: skeletal series shows no evidence of radiation osteitis. There are degenerative changes in a moderately advanced degree in the dorsal spine and about both knee joints, and lesser degenerative changes elsewhere. Some deformity of the upper fibula on the right side is noted most likely due to an old fracture. The heart and lungs appear normal. Conclusion: no evidence of radiation osteitis.

(01-210) Born 11 November 1878. Present Health: reasonably good, except for some inflammation around the external auditory canal of the left ear. Systems Review: Eyes: some blurring of vision of the right eye, since his attack of coronary thrombosis 2-1/2 years ago; this he attributes to the dicumarol medication which he received at that time. Vision of left eye normal. No other disturbances of his eyes. Ears: usually normal, but developed this infection in the left external canal during the past 5 or 6 days. Nose: normal at the present time. States that he had a radium burn inside the nose for several years, due to inhalation of radon gas; this has cleared up and caused no difficulty for the past several years. Throat: negative at present time, tonsils radiated with radium 20 years ago, with marked benefit. No history of swollen glands in the neck or elsewhere. CR: had a definite attack of coronary thrombosis 2-1/2 years ago, but he seems to have made a complete recovery. Now walks nearly 5 miles a day, or engages in similar vigorous exercise. No history of any cough or unusual dyspnea. GI: negative. Bowels somewhat constipated, takes Senokot medication for this condition quite regularly. No history of blood in the stools or melena. GU: essentially negative. NM: some hypertrophic arthritis of the terminal joints of the fingers. Skin: has had varying degrees of a mild eczematous dermatitis on the arms; this had been cured by ionized calcium lactate medication and ultraviolet light radiation. Habits: appetite good. Weight has remained approximately the same in recent years with diet. Sleeps fairly well at night. Does not smoke. Alcohol consumption minimal. Gets regular exercise as noted above. Past History: usual childhood diseases, but no specific history of scarlet fever, diphtheria, rheumatic fever or allergy. Believes he had typhoid fever twice. Has had malaria and dysentery. The last was very severe. He experienced this illness in Africa during the Boer War. No history of epilepsy or mental disorder. He states that he had an aplastic anemia in 1920, due to radium poisoning. At about this time he felt that his thyroid had been inactivated by the radium poisoning and as a consequence he started taking thyroid extract around 1920-25, and has taken thyroid medication almost continuously since that time. At the present time he takes approximately 2 grains daily. Operations: consist of appendectomy many years ago, and an operation on one of his frontal sinuses. No history of any fractures, other accidents, or injuries. Family History: father died at 74, cause not determined; mother died at 67 of a cancer. Seven siblings all older than himself have died, causes unknown, as they were living in

England. Marital History: married 54 years to the present time. Wife, 84, living but in poor health. One child born of this marriage, now 53 years old, living and well, who has four children and one grandchild. There were no other pregnancies from this marriage by design. Dental History: lost all of his teeth over the years, but only one or two at a time. Last remaining teeth removed approximately 15 years ago. He does not remember any particular trouble with healing of the sockets after removal of the teeth. Radiation Exposure: in 1918, when he was 40 years old, he went to work for a radium clinic and he continued to work for this group until 1957. His work consisted mostly of extracting the radon gas from the radium element. He had more or less continuous external radiation from these sources during all of this time.

Physical Examination: a robust, healthy-appearing man of 81, weight 146 lbs., height 64.5", BP 200/86, pulse 86 and regular. Eyes: pupils react normally and equally to light and accommodation, extraocular movements normal. Vision in right eye markedly diminished. Ears: right normal. Left ear shows moderate otitis externa of the left external auditory canal. Nose: normal. Teeth: all missing, wears full upper and lower dentures. Gums in good condition. Throat: negative. Neck: normal, no cervical adenopathy. Thyroid not palpable. Heart: moderately loud systolic murmur in the aortic area, rhythm regular. Lungs: clear. Abdomen: soft and relaxed. Liver and spleen not felt. Well-healed appendectomy scar, right lower quadrant. Inguinal rings normal. Genitalia: normal. Rectal: 2+ uniformly smooth enlargement of the prostate gland. Extremities: 1+ varicosities on left. Reflexes: equal and active. Skin: old burn, presumably due to external radiation on the forefinger of the left hand.

Lab. Findings: Urinalysis: sp. gr. 1.023, albumin 1+, sugar neg., 1-2 rbc/HPF, 1-2 wbc/HPF, 1-2 crystals/HPF. Hematology: wbc 7000, differential P66, L31, E1, M2, rbc normocytic, corr. sed. rate 33 mm/hr., hematocrit 45 percent. Blood chemistries: alk. phos. 4.5 units, BUN 28 mg percent, sugar 173 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.0, alb 4.47, TG 2.53, $\alpha 1$ 0.21, $\alpha 2$ 0.66, β 0.76, γ 0.90.

X-ray Findings: skeletal series shows no evidence of radiation osteitis. The patient is edentulous. There are very marked degenerative changes about the distal interphalangeal joints of the fingers and to a lesser degree about the proximal interphalangeal joints. In the latter case these changes could be degenerative in nature but superimposed on old rheumatoid arthritis. The other joints of the hand and wrist are normal in appearance

however, against this. The phalanges, however, are osteoporotic most likely due to lack of use. There are degenerative changes about the first metatarsal-phalangeal joint. There are other minor degenerative changes about the joints consistant with age. No other abnormalities are seen. Conclusion: no evidence of radiation osteitis is seen.

(01-211) Born 18 January 1907. Present Health: poor. Has a tendency to what he calls "sick spells" every 2-3 weeks requiring bed rest for 3-4 days. During these episodes he feels very weak and exhausted but without any other specific complaints. During most of this time of incapacitation he sleeps. These spells date from the time of his operation for esophageal varices when a spleno-renal shunt was done. As a complication of this operation he had a diaphragmatic abscess which required operation. He has had no further trouble with the esophageal varices since this operation, but has had the "spells" as noted above. He had two repairs of incisional hernias in 1951 and 1953 or 1954.
Systems Review. Eyes: some blurring of vision at night after a heavy meal. Ears, Nose, and Throat: negative. No history of any swollen glands in the neck or elsewhere. CR: negative except for a tendency to bronchitis. This resulted in one attack of bronchial pneumonia for which he was treated in 1958. GI: negative. Bowels constipated, but no history of any blood in the stools in recent years. GU: normal. NM: negative except for some tiredness of the legs after standing for any time. Skin: normal. Habits: appetite good, weight has increased some in recent years. Sleep is variable, usually tends to insomnia except when he is having one of his "sick spells". At these times he sleeps all day and all night. Tobacco consumption averages 20 cigarettes daily. Alcohol denied. No sports or other exercise. Past History: usual childhood diseases but no specific history of any scarlet fever, diphtheria, rheumatic fever, allergies, epilepsy, or mental illness. Prior to 1950 he had several hospital admissions for hematemesis. Eventually a diagnosis of esophageal varices was made resulting in the operation outlined above. No other operations, accidents, or injuries. No other hospitalizations except one for a broken rib many years ago. Family History: father died at 82, question cause; mother died at 70 of cancer. There are three siblings living and well. One sibling died in 1937, cause unknown. No other family history of cancer. No family history of diabetes, tuberculosis, mental disorder, or epilepsy. Marital History: married 24 years to present time. Wife is 55, has been

in a mental hospital for the past 10 years. No pregnancies have resulted from this marriage. Dental History: teeth have gradually deteriorated over the past 10 years, but he has never consulted a dentist for any repairs. Radiation Exposure: Thorotrast injection in 1950 for determination of liver function.

Physical Examination: well-developed, somewhat obese man, weight 180 lbs., height 65", BP 170/110, pulse 96 and regular. Eyes: pupils small, react poorly to light and accommodation, extraocular movements normal. Ears: negative. Nose and Throat: normal. Teeth in very poor condition. Many broken off at the gum margin, remaining teeth carious. Neck: no cervical adenopathy or thyroid enlargement. Chest: some rhonchi and occasional nonpersisting rales at both bases. Heart: slightly enlarged by percussion. No murmurs heard. Abdomen: multiple scars in the left upper quadrant and left flank. Liver enlarged approximately 4 finger breadths. No definite masses felt. Inguinal rings somewhat relaxed, right greater than left. Both testes in scrotum, but seem small and somewhat atrophic. Prostate small. Rectal examination otherwise negative. Extremities: legs show some superficial varices. Reflexes: sluggish, but present on both sides. Romberg negative.

Lab. Findings: Urinalysis: sp. gr. 1.027, albumin neg., sugar neg., 2-4 rbc/HPF, little mucous. Hematology: wbc 7100, differential lab. error, corr. sed. rate 35 mm/hr., hematocrit 42 percent. Blood chemistries: alk. phos. 12.4 units, BUN 18 mg percent, sugar 152 mg percent, TT 1.0 units, Hinton negative. Electrophoresis (grams percent): TP 6.1, alb 3.22, TG 2.88, $\alpha 1$ 0.18, $\alpha 2$ 0.48, β 0.74, γ 1.48.

X-ray Findings: skeletal series shows the liver to be denser than usual but in an inhomogeneous fashion with islands within the liver which are not dense. The liver appears smaller than normal. The spleen is not seen. Numerous lymph nodes along the upper lumbar and lower dorsal spine show increased density in a speckled fashion. The left costophrenic angle is obliterated, and there is evidence of surgery involving the lower ribs on the left side with numerous wire loops. The semilunar bones of both wrists show some degenerative changes. The bones show no evidence of radium poisoning. The remaining teeth show caries and numerous retained root fragments, and there is evidence of periapical disease but no evidence of radium poisoning. Summary: this patient shows evidence of old Thorotrast injection, and he probably had a splenectomy. It is believed the appearance of the liver could be explained as cirrhosis, but is also conceivable,

although less likely, that metastasis is present within this small liver. The appearance of the retroperitoneal lymph nodes most likely is produced by Thorotrast which has migrated into these nodes.Conceivably it could be due to old tuberculosis.

(01-212) Born 1 January 1894. Present Health: fair. He has retired from the active practice of dentistry because of a coronary attack in 1953. He still is troubled with frequent minor episodes, principally in the form of angina pectoris. He has a long history of many serious illnesses which will appear below.

Systems Review: review of the systems at the present time as opposed to past history is as follows. Eyes: essentially normal. Ears: no difficulty at the present time, but has been treated for attacks of Meniere's syndrome, last episode one year ago when he spent 3-4 weeks in getting over a very severe attack. Nose: normal. Throat: negative. No history of any swollen glands in the neck or elsewhere. CR: no cough. Chest pain in the form of angina relieved by nitroglycerine, taking anywhere from 3 to 10 tablets a day. Some dyspnea on exertion. No ankle edema. GI: no indigestion, nausea, or vomiting. At the present time bowels are fairly regular, takes a daily enema. This has been necessary since operation for rectal abscess 16 years ago. GU: negative at the present time. No nocturia, urgency, or frequency. NM: occasional joint pains and stiffness, but no definite arthritis. Skin: negative. Habits: appetite good, no weight change in recent years, but there has been a gradual loss from 196 to 136 lbs. at the present time. Most of this weight loss occurred 8-9 years ago. Sleeps fairly well at night. Tobacco consumption minimal. Alcohol consumption minimal to none. Gets very little exercise. Past History: had always been well until the age of 49 in 1943 when he developed an ischiorectal abscess. He was admitted to the hospital because of this, and because of various complications remained hospitalized for the next 18 months. In the course of this long period of hospitalization, he had 3 operations for the ischiorectal abscess, developed a septicemia, and following this, developed an abscess in the lung, an abscess in the liver, and a diaphragmatic abscess. All of these conditions required operations. In the course of the investigation of the liver he was given an injection of Thorotrast at the age of 51 in the year 1945. Because of the extensive hospitalization he became addicted to barbiturates, and later on, at the age of 57, because of the difficulty with the bowels be became addicted to

wbc/HPF, 0-1 rbc/HPF, mucous threads. Hematology: wbc 5200, differential P67, L31, E1, M1, rbc normocytic, corr. sed. rate 4 mm/hr., hematocrit 44 percent. Blood chemistries: alk. phos. 6.8 units, BUN 18.5 mg percent, sugar 121 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.7, alb 4.05, TG 2.65, α1 0.25, α2 0.49, β 0.63, γ 1.28. Thymol turbidity, Cephalin flocculation: TT 3.0 units, CF 24 hrs. neg., 48 hrs. 1+.

X-ray Findings: skeletal series shows the following abnormalities: there are deposits of thorium in the spleen, liver, and some mediastinal and abdominal lymph nodes. There is a deposit of metal most likely thorium at the medial aspect of the lower leg just above the ankle. This may have been extravasated at the time of a Thorotrast injection at some time in the past. No evidence of radiation osteitis is seen. The skeleton shows no other abnormalities except for some minor degenerative changes. Conclusion: Thorotrast is present in the reticuloendothelial system and probably the right lower leg. There is deformity of the right 9th rib as a result of an old thoracotomy.

(01-213) Born 14 November 1894. Present Health: poor and has been for several years. Complaints center chiefly around varying degrees of asthma for 5 years, some weight loss, cause unknown, for the past 5-6 years, and a so-called frozen shoulder on the right for the last 10 months. Weight loss was investigated one year ago. At this time, x-rays were taken and considerable laboratory work was done. No definite cause was found for the weight loss. During this time a gland was removed from the region of the left groin. Report was presumably negative. During the past eight months he has had varying degrees of difficulty with pain and limitation of motion of the right shoulder. Further x-rays were taken of this region. Systems Review. Eyes: left eye normal. Right eye vision practically nil since operation in 1934 for an aneurysm of one of the blood vessels around the base of the brain. Ears: negative. Nose and Throat: normal except for several attacks of quinsy sore throat in the past, none recently. Neck: no known swollen glands in the neck, but there has been a firm swelling under the angle of the jaw on the right since the operation noted above. There was also one gland removed from the left groin (see history above). CR: asthma for several years which is particularly troublesome in the summer months. GI: occasional indigestion relieved by Amphojel. There was a history of a questionable duodenal ulcer 10 or more years ago At the present time, no ulcer symptoms. No nausea or vomiting. Bowels

paregoric. With great effort he gradually rid himself of both of these addictions. In 1951 at the age of 57 he developed a toxic goiter, and for this was treated with radioactive iodine. At the age of 58 he had a trans-urethral resection of the prostate because of prostatic hypertrophy. A year later, at the age of 59, he developed a coronary thrombosis and has suffered varying degrees of angina pectoria since recovering from this episode. In 1954 at the age of 60 he had trouble with barbiturate addiction again, culminating in an admission to the hospital at the age of 64 in 1958 where he remained for several weeks. He states that he is now free from this barbiturate addiction. In addition to the above illnesses, he had the usual childhood diseases, but no specific history of scarlet fever, rheumatic fever, diphtheria, epilepsy, allergies, or mental disorders other than the addictions as noted above. Family History: father died at 72 of coronary thrombosis; mother died in her mid-80's, cause not known. Two siblings died of coronary artery disease at ages 52 and 53; two brothers living, one with heart disease, two sisters living and well. No family history of cancer, tuberculosis, diabetes, allergy, epilepsy, or mental illness. Marital History: married 39 years to the present time. Two boys, aged 39 and 29, both living and well and single. Dental History: has lost approximately 12 teeth over the years, one or two at a time. No trouble with healing of the sockets after extractions. Radiation Exposure: received one injection of Thorotrast as noted above in 1943 or 1944. Received radioactive iodine therapy for toxic goiter in 1951.
Physical Examination: a well-developed, rather thin man of 65; weight 136 lbs., height 66", BP 112/70, pulse 76 and regular. Eyes: pupils react normally and equally to light and accommodation. Extraocular movements normal. Ears: negative. Nose: negative. Throat: negative. Remaining teeth in good repair. Neck: no cervical adenopathy. Thyroid not palpable. Heart and Lungs: normal to auscultation and percussion. No murmurs heard. No irregularities of the pulse. Abdomen and lower thorax show multiple postoperative scars all well-healed; namely, in the right posterior chest, right upper quadrant, epigastric region, and right lower quadrant. No masses felt. Liver and spleen not made out. Inguinal rings normal. Genitalia: normal. Rectal: multiple scarring and loss of tissue substance around the anus. Some excoriation of the skin around the anus.
Rectal examination difficult to make out landmarks. Prostate not palpable. Extremities: normal. Reflexes: equal and active. Romberg negative.
Lab. Findings: Urinalysis: sp. gr. 1.018, albumin neg., sugar neg., 1-2

regular except for occasional bleeding from external hemorrhoids. GU: some urinary frequency in the daytime due to nerves. Nocturia once only. NM: negative except for the pain and limitation of motion in the region of the right shoulder (see Present Health). No history of any headaches or paresthesias. Skin: no abnormalities. Habits: appetite fair, weight has remained about the same in the past year. Sleeps soundly at night. Smokes 10-15 cigarettes daily, alcohol consumption nil for the last 7 years. Gets plenty of exercise in the course of his work as building superintendent. Past History: usual childhood diseases but no specific history of diphtheria, rheumatic fever, scarlet fever, epilepsy, or mental disorder. Allergy as noted above. Operations: see Present Health. He also had bilateral amputation of the 2nd toe for hammer toe in 1915 while in Canada. He had one accident while working as a hod carrier 20 years ago when an elevator cable broke and he dropped many feet to the ground. This caused some disorder to one knee. This has since recovered without further difficulty. No other hospitalizations other than those noted above. Family History: father died at 86, cause undetermined; mother died at 62 of cancer. Eleven siblings altogether, seven are living and fairly well, all over age 65, oldest is 80. Four died at birth. No other family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married 25 years to present time; wife, aged 64, living,with arthroplasty of one hip following a fracture. No pregnancies at any time, reason not known. Dental History: lost all of his teeth in Canada before the age of 20 and has been wearing dentures ever since. Radiation Exposure: received an injection of Thorotrast in 1934, at the time of the operative repair of the aneurysm in the neck. No other radiation exposure.

Physical Examination: a thin, but otherwise healthy-appearing man of 65, weight 106 lbs., height 65", BP 118/70. Eyes: marked diminution of vision on right. Left eye normal. Ears: negative. Nose and Throat: normal. Teeth all missing, with full upper and lower dentures. Neck: firm, rather indurated, scar right side of the neck, presenting from the mastoid region down to the clavicle. There is a small moderately firm gland in the left anterior cervical chain. Chest: some diminution of breath sounds throughout, but no other definite pathology revealed. Heart: normal to auscultation and percussion. Abdomen: negative. Liver and spleen not felt. Inguinal rings normal. Genitalia: normal. There is a well-healed scar in the left groin, site of biopsy of inguinal gland. Rectal: small

prostate, some external hemorrhoids. Extremities: bilateral amputation of 2nd toe. Reflexes: equal and active. Romberg negative.
Lab. Findings: Urinalysis: sp. gr. 1.012, albumin neg., sugar neg., little bacteria, amorphous phosphates. Hematology: wbc 9900, differential P57, L40, E2, M1, rbc normocytic, corr. sed. rate 32 mm/hr., hematocrit 41 percent. Blood chemistries: alk. phos. 10.0 units, BUN 17 mg percent, TT 1.1 units, sugar 115 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.2, alb 4.0, TG 2.2, $\alpha 1$ 0.21, $\alpha 2$ 0.51, β 0.70, γ 0.78.
X-ray Findings: skeletal series shows the following abnormalities: the left second toe has been amputated. There is a bilateral splayfoot deformity. The upper ends of both tibias shows some reticular densities either of no significance or possible represent old bone infarcts. There is a deposit of heavy metal in the right side of the neck. The appearance suggests that the patient has had a carotid angiogram at some time in the past with Thorotrast which extravatated. The films of the liver and spleen are not included in this series. No evidence is seen in the skeleton of radiation osteitis.

(01-214) Born 7 November 1890. Present Health: good and has been for many years. Can remember no illnesses at all in the past 10 years. Systems Review. Eyes, Ears, Nose, Throat: no abnormalities of note. No history of any swollen glands in the neck or elsewhere. CR: normal GI: negative. Bowels regular except for occasional slight rectal bleeding due to hemorrhoids. GU: negative, except for rare nocturia. NM: normal. Skin: marked psoriasis for the past 2-3 years. Habits: appetite good, weight remains same. Sleeps at night. Smokes about 10 cigarettes daily. Alcohol consumption one drink daily. Exercise consists of regular walking. Past History: usual childhood diseases. No specific history of scarlet fever, diphtheria, rheumatic fever, allergy, epilepsy, or mental disorder. Operations: appendectomy at age 22. No history of any accidents, injuries, fractures, or other hospitalizations. Family History: father died at 78 of heart disease; mother died at 76 of a stroke. Two brothers and one sister living and well. One brother had an operation for cancer of the rectum with successful operative results. No other family history of cancer. No history of tuberculosis, diabetes, allergy, epilepsy, or mental disorders. Marital History: married for the first time at age 23 for a period of 11 years until 1934. One boy born of this marriage now living and well, age 46. Marriage terminated in divorce. Second marriage for a

period of 14 years from age 52 to 66. No children born of this marriage. Dental History: began to have trouble with his teeth in adolescence resulting in the extraction of all teeth by age 23. He has worn dentures ever since that time. Radiation Exposure: he was engaged in crystallization and other radium processing in 1915 at age 26, for a period of 8.5 years. He then was away from any contact with radium for a period of 16 years. He returned in 1942 at the age of 52 and worked until his retirement in 1958 at the age of 68. During this time he had various duties in the processing of various radium products.
Physical Examination: a well-developed and nourished, healthy-appearing man of 69, weight 145 lbs., height 62", BP 170/100, pulse 84 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Teeth all removed, wears full upper and lower dentures. Neck: no cervical adenopathy or thyroid enlargement. Lungs clear to auscultation and percussion. Heart: grade 2 to grade 3 systolic murmur, best heard in the aortic area, but audible over the entire precordium. Abdomen: soft and relaxed, no masses felt, liver and spleen not made out, well-healed appendectomy scar in right lower quadrant. Inguinal rings normal. Genitalia: question of slight hydrocele on right. Rectal: some external hemorrhoids and 2-3 plus enlargement of prostate. Extremities: normal. Reflexes: equal and active. Romberg examination negative.
Lab. Findings: Urinalysis: sp. gr. 1.025, albumin neg., sugar neg., 1-2 rbc/HPF, occ wbc/HPF, little mucus. Hematology: wbc 5800, differential P55, L30, E10, M5, rbc normocytic, corr. sed. rate 24 mm/hr., hematocrit 45 percent. Blood chemistries: alk. phos. 7.4 units, BUN 17.5 mg percent, sugar 115 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.8, alb 4.38, TG 2.42, $\alpha 1$ 0.30, $\alpha 2$ 0.60, β 0.78, γ 0.74.
X-ray Findings: skeletal series shows no evidence of radiation osteitis. Except for degenerative changes consistent with the patient's age, no abnormalities are seen in the skeleton. The abdominal aorta is rather heavily calcified, and is quite tortuous. The heart is enlarged and the thoracic aorta is also calcified. There is some density behind the heart; this may represent hiatus hernia. Another possibility would be a posterior mediastinal mass.

(01-215) Born 19 March 1898. Present Health: fairly well. She has, however, for 5-6 years had dyspnea with exertion. She is unable to go up more than one flight of stairs without stopping. She has no orthopnea,

she sleeps on two pillows. Three years ago a chest x-ray was said to be negative; an electrocardiogram was said to show some nervousness. Since that time she has taken digitalis daily. Has also been asked to take a pill for excess fluid regularly. Feels there is a diuresis after taking these pills. She also complains of a whitish phlegm about her mouth and on her teeth in the past 2-3 months. She has apparently been told that she has chronic bronchitis.

Systems Review. Eyes: normal except for occasional blurring. Ears, Nose, and Throat: negative. She denies any swollen glands about her body. CR: see above. GI: appetite is fair; her weight has been steady in the range 133-127 for the past two years. Before that she weighed 153 lbs.for some 25 years. She has excessive belching (gallbladder x-rays were negative four months ago). She has been told she has rectal polyps and notes occasional rectal burning. GU: negative. Allergy symptoms denied. Endocrine: negative. NM: patient turned her foot while walking about 4 months ago and sustained a fracture of the ankle. She was in the hospital for eight days. There was good healing and good recovery from this accident. She has often suffered from varicose veins of the right leg, has had an ulcer above the ankle on that leg. Habits: patient smokes one package of cigarettes per day, has about two cocktails per day, drinks three cups of coffee per day. General strength was good. Past History: states she had a D and C some 30 years ago because of back symptoms; symptoms were cured. She usually has two severe colds a year. Has had no other broken bones, except the ankle as mentioned above. No other operations. Family History: father died with heart disease at age 74; mother died with heart and lung disease at age 78. She had only one sibling, a brother, age 51, who is well except for cataracts. One daughter has kidney stones. No history of cancer, tuberculosis, diabetes, epilepsy, or allergy in the family. Marital History: patient was married at age 18.5 years. Her husband died about 5 years ago when the patient was 56. She had three children, who are all well; their ages are 30, 35, and 40. Her pregnancies and deliveries were unremarkable. Dental History: states that she always had soft teeth, remembers that she began to have crowns on them about age 17 or 18. The upper teeth were all removed between the ages of 25 and 30 years. All the lower teeth were removed at about the age of 30. She does not remember having had dental x-rays at any time. There has been no pain in the jaws. Radiation Exposure: worked as a dial painter from 17 November 1925 to 3 December 1925 at age 27. She is unable to remember the jobs she

had at that time and is unable to remember whether she worked with the radium paint brushes or not. She noticed no glowing of the hair or clothing at night.

Physical Examination: a well-developed, very well-nourished woman with appearance of stated age of 61, weight 132 lbs., BP 140/70 (left arm), pulse 80 per minute and regular. HENT: pupils react sluggishly to light. Retinal examination shows narrowing of the arterioles and some A-V nicking. No papilledema, hemorrhages, or exudate. Nose and Throat: normal. The patient is completely edentulous. She had full dentures. Thyroid gland was not felt. There was increased PA diameter of the chest with fair expansion. Breath sounds were distant; there were rales at both lung bases. The heart was not enlarged clinically; regular sinus rhythm of 80 per minute. Sounds were distant. First sound was good at the apex. Abdomen: tight musculature, liver one finger-breadth below right costal margin; spleen not felt. Pelvic: erythematous, smooth labia majora. Marital introitus which appeared to have been surgically made smaller. There was a whitish discharge about the cervix. Rectal: external hemorrhoids, otherwise negative. She had no ankle edema. She had varicose veins, most prominent on the right medial lower leg. An old ulcer was present in the same location. Reflexes were equal and active. There was no lymphadenopathy.

Lab. Findings: Urinalysis: sp. gr. 1.012, albumin neg., sugar neg., 2-4 epith/HPF, occ rbc/HPF. Hematology: wbc 9100, differential P49, L45, E2, M4, rbc normocytic, corr. sed. rate 29 mm/hr., hematocrit 45 percent. Blood chemistries: alk. phos. 4.8 units, BUN 11 mg percent, sugar 117 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.0, alb 4.32, TG 2.69, $\alpha 1$ 0.21, $\alpha 2$ 0.58, β 0.82, γ 1.08.

X-ray Findings: skeletal series shows the following abnormalities: the chest is normal except for slight tortuosity of the aorta and minimal degenerative changes in the dorsal spine. The skull has a rather granular appearance. The changes are probably within normal limits, although conceivably there could be very minimal osteitis. The sinuses appear normal. The patient is edentulous. The lumbar and dorsal spine as well as the pelvis are normal except for minimal degenerative changes. The extremities show calcification in the region of the right subdeltoid bursa and equivocal lacunar changes in the upper ends of the tibia and the lower ends of the radius and ulna. These may be either due to mild osteoporosis or very minimal radiation osteitis. The right 2nd toe has been amputated. Con-

clusion: doubt that the changes described are due to radiation osteitis. If so, they are very minimal and confined to the skull, legs,and forearms.

(01-216) Born 26 March 1903. Present Health: fairly well, but has noted a gradual weight loss since a subtotal gastrectomy 13 years ago. Weight then was 105 lbs., weight one year ago 95 lbs., present weight 92 lbs. Appetite is good. She also complains of frequent and easy sweating. She sweats at night, but usually above the neck. She has no fever or shaking chills. In addition, she has noted for about two years episodes of vertigo which last two to three minutes and tend to occur any time during the day. During these episodes, she may stagger, but has not had any nausea or vomiting. She also notices a buzzing in her ears, and a decrease of hearing, worse on the left than on the right. Hearing loss has been progressive during her life, has been worse in the past couple of years. She also complains of two months of sharp right neck pain when she turns her head. At such times she also hears a clicking noise. The area is occasionally tender to the touch.
Systems Review. HENT: the buzzing of the ears and vertigo has been mentioned above. She had many earaches as a child, but no chronic discharging ears. CV: she has dyspnea after one flight of stairs. No orthopnea or ankle edema. GI: appetite is very good; she eats most kinds of foods. No symptoms of the dumping syndrome. GU: pyelitis as mentioned below. She also has occasional stress incontinence of urine after sneezing or coughing. NM: she has left elbow aching, also the neck pains as mentioned above. Has never had any fractures of the bones. Lost her right thumb in an accident at the age of 16. Lymph: notes swelling several times a year of the lymph glands under both ears. She has also had swelling over the parotid area on the right. Endocrine: some decrease of axillary hair. Habits: she smokes one pack of cigarettes per day, drinks about one glass of beer a day. She takes no medicines regularly except Aspirin for her nerves and to sleep at night. Past History: operations - appendectomy, age 16; submucous resection and T and A about 15 years ago; hysterectomy and partial oophorectomy in 1942; subtotal gastrectomy in 1946, this operation was preceded by 3-1/2 years of symptoms and by a 30 lb. weight loss; she denies hematemesis or melena but was told that she had a bleeding ulcer. At that time, she also had a biopsy of the left neck lymph node, result is not known. Hospitalizations: in 1943 she had cystitis and pyelitis. No symptoms since. About three years ago she had pneumonia and pleurisy twice;

a first attack three years before that was treated at home. Symptoms have always been on the left side. In addition, at the age of 16, she spent a year as a patient at a tuberculosis sanatorium, was told she had a very slight tuberculosis. She spent another year at that hospital working. X-rays since then have apparently shown no change in the scar tissue. Family History: father died with pneumonia at age 38; mother died at age 43, causes uncertain. Cancer, tuberculosis, diabetes, epilepsy, kidney disease in the family denied. She had 11 siblings, three died as babies, one died as a result of an accident at age 14; the others are in good health except for a sister who tends to have asthma. Marital History: she has been married for 18 years. There have been no children and no pregnancies. Dental History: members of her family tend to have good teeth. Patient began to have aching of teeth, and cavities, at about age 36. In the next ten years, she had 16 teeth out at various times. Seven or eight years ago she had 14 teeth out. She now has two remaining lower teeth. She has had no abscesses. Radiation Exposure: from 14 February 1924 to 10 March 1924 at the age of 20 patient used paint brushes with radium, and pointed the brushes with her mouth. During that time she would notice a glowing of the apron that she wore, at night. No glowing of the hair was noticed. This patient has also had chest x-rays, two to three a year for the past 18 years, about 1 a year previously. She has had an upper GI series three times, a barium enema once, and apparently an IVP once.

Physical Examination: a well-developed, thin and pale woman, weight 91-3/4 lbs., height 63-1/4" (used to be 65"), BP 128/102, pulse 80 per minute and regular. HENT: there was some narrowing of the arterioles on retinal examination. Nose and Throat: negative. Patient was edentulous except for two lower front teeth. Thyroid not palpable. There was a small linear scar near the angle of the jaw on the left. When the patient turned her head to the right, there was a perceptible click. There was a minimal tenderness of the area about C5 in the surrounding muscles. Chest: slightly kyphotic, good expansion of the lungs, no rales heard. There was a pectus excavatum of mild degree. Heart not remarkable. No masses felt in the breast. The liver and spleen were not felt. She was slightly tender in the right costovertebral angle area, and it is possible that the right kidney is palpable. The patient had well-healed subtotal gastrectomy scar, a suprapubic midline scar, and a RLQ appendectomy scar. Pelvic: a marital, nonparous introitus; a cervical stump was felt and held at the left side

of the vaults of the vagina; it was slightly tender; there was a whitish-gray discharge. Rectal: hemorrhoidal tags were present, no other abnormalities noted. Extremities: the right thumb was missing with a stump left at the base. Both little fingers had radially deviated distal phalanges. Dorsalis pedis pulses were good. CNS: unremarkable.
Lab. Findings: Urinalysis: sp. gr. 1.020, albumin neg., sugar neg., 5-10 epith/HPF, 5-8 wbc/HPF. Hematology: wbc 7500, differential P80, L18, M2, rbc normocytic, corr. sed. rate 5 mm/hr., hematocrit 45 percent. Blood chemistries: alk. phos. 5.6 units, BUN 11.8 mg percent, sugar 114 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.7, alb 4.03, TG 3.36, $\alpha 1$ 0.24, $\alpha 2$ 0.31, β 0.59, γ 2.22.
X-ray Findings: skeletal series shows the following abnormalities: the heart and lungs are normal in appearance. The dorsal spine, lumbar spine and pelvis show no abnormalities except for minimal degenerative changes. The skull is normal in appearance. The sinuses are normal. The patient is edentulous. The hands are normal. The right thumb has been amputated. There are equivocal lacunar changes in the distal radius and ulna on either side. The upper half of the shaft of the humerus on each side shows equivocal lacunar changes. The upper ends of the radius and ulna are normal in appearance. Conclusion: the abnormalities seen can be explained by osteoporosis alone. It is possible that radiation osteitis could produce the minimal lacunar changes described.

(01-217) Born 21 December 1894. Present Health: patient, who is now retired, states that his present health is good, but he had had a lot of trouble with kidney stones up until 6 months ago for a period of many years. Systems Review. Eyes: no difficulties with eyes, ears, nose or throat. No history of any swollen glands in the neck or elsewhere. CR: has known that he has had a heart murmur since childhood, but this has never caused him any trouble; it did not interfere with his induction into the Army in World War I. GI: negative. Bowels regular without laxative, no history of any blood in the stool. He had a hemorrhoidectomy 9 months ago from which he made an uneventful recovery. GU: has had trouble with kidney stones starting in 1940, when he was 46 years old. He has had several bouts of renal calculi, resulting in 3 hospitalizations; the last time was in July 1958. He developed a moderately severe infection of his GU tract following a cystoscopy and or a pyelogram. This eventually cleared up, although he was laid up for nearly 6 weeks. He has had no difficulty since

that time. NM: some arthritis in the lower back and elbows. No skin abnormalities. Habits: appetite good, alcohol consumption consists of a small amount of beer daily. Gets only a minimal amount of exercise. Past History: usual childhood diseases, but no specific history of scarlet fever, diphtheria, or rheumatic fever. No allergy, epilepsy, or mental disorder. No operations, accidents, injuries,or fractures. Only hospitalizations are those referred to in the Systems Review with respect to renal stones. Family History: father died, 50, of heart disease; mother, 93, living and well. One half brother, living and well. No family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental illness. Marital History: married 42 years to present time. Wife, 62, very much crippled with arthritis. Three children ages 40, 37, 34. Two married children both have children of their own, all living and well. Dental History: has lost approximately 12 permanent teeth during his lifetime, no trouble with healing after extraction. Radiation Exposure: he first was exposed to radium in 1914 at the age of 20, when he was apprenticed to the job of dial painting. He remained at this type of work, painting luminous dials, until 1918, when he was inducted into the Armed Forces, during World War I. When he returned, he did some dial painting off and on for the next 30 years, using approximately 50 g of luminous paint annually in the business which he then owned. He denies ever putting the brush in his mouth at any time. He believes that he was reasonably careful in the use of luminous paint at all times.

Physical Examination: a well-developed and nourished, vigorous-appearing man of 64, height 66", weight 172 lbs., BP 138/88, pulse 78. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Remaining teeth in good repair. Neck shows bilateral submaxillary plans, nontender. Thyroid not palpable. Heart: soft systolic murmur, otherwise negative. Lungs: clear and resonant. Abdomen: soft and relaxed. Liver and spleen not felt. There is a moderately large inguinal hernia on the right. There is also a hydrocele on the right side. Left inguinal ring and testicle normal. Rectal: prostate and hematest negative. Extremities: moderate sized varicosities in both calfs. Reflexes: equal and active. Skin: multiple, small pigmented nevi over entire body. There is a small keloid formation measuring approximately 1-1/2 cm in diameter over the right shin below the knee.

Lab. Findings: Urinalysis: sp. gr. 1.023, albumin neg., sugar neg., 1-2 wbc/HPF, 1-2 rbc/HPF. Hematology: wbc 6500, differential P52, L42, E3,

M3, rbc normocytic, corr. sed. rate 11 mm/hr., hematocrit 46 percent. Blood chemistries: alk. phos. 5.2 units, BUN 14 mg percent. sugar 101 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.9, alb 4.25, TG 2.65, $\alpha 1$ 0.37, $\alpha 2$ 0.54, β 0.79, γ o.95.
X-ray Findings: skeletal series shows there is no evidence of radium poisoning. Incidental findings are: some slight cardiac enlargement without evidence of failure, an innocent bone island in the proximal metaphysis of the left tibia, some degenerative changes about the greater tuberosities of both humeri, evidence of old healed fractures of both first metacarpal bones. Films of the remaining teeth show no evidence of radium poisoning.

(01-218) Born 24 September 1924. Present Health: good and has been in recent years except for the operative removal of his left parotid gland in February 1959 because of an infection. He states definitely that no malignancy was found. He made an uneventful recovery from this operation and has had no further difficulty since that time.
Systems Review. Eyes: he has been troubled with some chronic granulation of the eyelids since childhood, but this has not caused much difficulty in recent years. No abnormalities of the ears, nose, or throat. No history of any swollen glands in the neck or elsewhere other than the infected parotid gland noted in the present illness. CR: negative. GI: normal; bowels regular without laxatives, no history of any blood in the stools. GU: normal. NM: negative. No skin abnormalities. Past History: usual childhood diseases, but no specific history of scarlet fever, rheumatic fever, diphtheria, allergy, epilepsy, or mental disorder. He had one fractured clavicle on the left in childhood. No other fractures noted. Only hospitalization or operation was the removal of the parotid gland noted in Present Health. Family History: father, age 63, living after an operation for cancer. Mother, age 59, living and well. One sister, living and well. No other family history of cancer. No family history of diabetes, tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married 15 years to the present time. Wife, age 32, living and well. Two children, ages 11 and 6, living and well. Dental History: he has had a moderate number of fillings in the course of his lifetime, but has lost only five of his permanent teeth to the present time. No trouble with healing after extractions. Radiation Exposure: he has had considerable contact with radium compounds for a year and a half, in 1950 at age 26. He is not certain whether there was any ingestion of these radium

compounds or not. He has also worked with other radioisotopes, but in very minute amounts at varying times since 1950.
Physical Examination: a well-developed and nourished man of 35, weight 181 lbs., height 69", BP 116/82, pulse 86 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Teeth in good repair. Neck: no thyroid enlargement. There is a scar in the left anterior cervical triangle, site of operative removal of the parotid gland, left. This is well healed, no sign of any swelling at present. Heart and Lungs: normal to auscultation and percussion. Abdomen: soft and relaxed. Liver and spleen not felt. Inguinal rings normal. Genitalia: normal. Rectal: not done. Reflexes: equal and active. Extremities: normal.
Lab. Findings: Urinalysis: sp. gr. 1.025, albumin neg., sugar neg., 3-6 wbc/HPF, few epith/HPF. Hematology: wbc 7200, differential P65, L35, rbc normocytic, corr. sed. rate 19 mm/hr., hematocrit 45 percent. Blood chemistries: alk. phos. 4.2 units, BUN 11 mg percent, sugar 91 mg percent, TT 1.6 units, Hinton negative. Electrophoresis (grams percent): TP 6.6, alb 4.10, TG 2.50, $\alpha 1$ 0.12, $\alpha 2$ 0.35, β 0.72, γ 1.31.
X-ray Findings: skeletal series which includes the axial skeleton and long bones and films of the chest shows no evidence of radiation osteitis. The skeleton is normal in appearance. Films of the teeth show no evidence of radiation osteitis.

(01-219) Born 22 August 1910. Present Health: good, works regularly, feels well. Ten years ago she had an abdominal operation which she thinks involved a suspension of her uterus, also had an appendectomy at the time, and there was a question of whether a tumor was removed.
Systems Review. HENT: patient wears bifocals. Her sight has been good, but in past four years has had some difficulty with close work. Ears: stopped-up feeling of the right ear in the past few months. Nose and Throat: negative. CV: negative. GI: fair appetite all of life; tends to vomit easily, but no specific food intolerances. Occasionally has diarrhea, but usually tends to be constipated. No jaundice or abdominal pain, or other GI symptoms. GU: patient thinks she may have had a kidney infection some 27 years ago. About five or six years ago she had a slight amount of hematuria treated by her doctor by injection, no symptoms since. Catamenia: periods are regular, occur every 28 $\pm$ 2 days, last two to three days accompanied by minimal symptoms of discomfort. Allergy: no known re-

actions to medicines, has had penicillin. No history of hives, hay fever, or asthma. Endocrine: negative. NM: no fractures. Habits: smokes about 1/2 pack of cigarettes per day in the last five years. She rarely drinks alcoholic beverages, drinks minimal amounts of coffee, tea, and milk. Her weight stays steady in the range of 105-115 lbs. Past History: one operation as noted above. No serious illnesses. Family History: mother is 67, father is 70; both are living and fairly well. No history in the family of cancer, tuberculosis, diabetes, allergy, or epilepsy. She has three sisters and two brothers, all living and well. Marital History: has been married for 30 years. Has one daughter, age 26, and one grandchild. No other pregnancies or miscarriages. Dental History: patient states that her teeth have been in good shape up to the past seven years when they began to have many decayed areas. She has an upper and lower bridge with four false teeth in each. Her other teeth are in good shape. Radiation Exposure: patient was employed from 21 September 1927 to 30 November 1927 painting clock dials, working with the paint brushes and radium, when she was 17 years old. Patient did not like the work and transferred after the short time that she was in that department. No memory of glowing hair or clothes. She has not worked with other types of radiation during her life. Physical Examination: a well-developed, well-nourished woman who appears to be in good health, weight 114 lbs., height 59.5", BP 112/78, pulse 84 per minute and regular. Skin was tanned and of normal texture. No significant lymphadenopathy. HENT: wears bifocal glasses; the retinae appeared normal. Ears: hearing was good, the right canal was blocked by cerumen. Nose: appeared normal. Throat: right tonsil was slightly larger than the left; both palatoglossal folds were injected. Teeth appear to be in good repair except for the upper and lower bridges, each containing four artificial teeth. The thyroid gland was just palpable. Chest: negative. Heart: regular rhythm, 80 per minute, no murmurs, sounds were clear. Abdomen: liver and spleen were not felt. There was a well-healed suprapubic midline scar; no masses or tenderness. Pelvic and Rectal: not done. Extremities: cool, moist palms. CNS: deep tendon reflexes were brisk and equal, flexor plantar responses, light touch and vibratory sensation normal.
Lab. Findings: were inadvertently omitted.
X-ray Findings: skeletal series that includes the skull, spine, and extremities as well as the chest shows no evidence of radiation osteitis. The heart and lungs are normal in appearance and the skeleton shows no abnormalities. The remaining teeth show no evidence of paridental disease

except for the last remaining lower left molar which shows some retraction of the alveolar process. There is a retained root fragment in the right upper cuspid or bicuspid area. The bone shows no abnormality.

(01-220) Born 28 September 1907. Present Health: feels in fairly good health. She does have chronic symptoms of epigastric and retrosternal burning. She states that a large hiatus hernia was found on upper g.i. series in November 1958. She is also bothered by headaches about once a week at present which are usually frontal, occasionally occipital, are throbbing in nature relieved by temporal pressure and by heat and rest. Aspirin will also relieve these headaches.
Systems Review. HENT: headaches as above. She wears glasses. She has a chronic itching and moistness of the right ear canal. Nose: she has noticed a blocking and stuffy feeling of her nose for some years. She sustained a traumatic fracture of the nose at age 18. She had an operation for a deviated septum about one year ago. Some of her symptoms still continue. Throat: no dysphagia or odynophagia. She has noted that her voice has been gradually getting deeper so that she has not been able to sing during the past two years. No history of goiters. CV: mild dyspnea after two blocks walking or two flights of stairs. No orthopnea. She also feels an occasional jumping of the heart. GI: appetite good. Weight has been in the vicinity of 210 to 216 lbs. With dieting she has been able to go down to 147 lbs. Weight has been steady in the past year. She has occasional regurgitation of food apparently associated with her hiatus hernia symptoms. GU: no history of infections or stones. She voids 4 to 5 times a night. The desire to urinate comes on while she is awake. Catamenia: periods have never been regular because of excess bleeding. A hysterectomy was done 3 years ago. Fibroid tumors were found. No bleeding or discharge since. Allergy: she has had itchiness of the skin after penicillin, treated with benadryl. Endocrine: no history of thyroid disease. Voice has been becoming more low. No other symptoms of thyroid disease. No history of neck lumps. NM: traumatic fracture of nose at age 18. No other known fractures, no bone pain. Habits: she does not drink or smoke. Milk and cheese intake is minimal. She has stopped drinking coffee and tea. Medicines: she uses Pro-banthine and Maalox for relief of epigastric burning, Benadryl and Neosynephrine nose drops for stuffiness of the nose, aspirin no more than 4 a day is used for headaches. Past History: operations - appendectomy about age 6, tonsillectomy

about age 25, hysterectomy 3 years ago, cholecystectomy for gallstones 2 years ago, probably nasal submucous resection 1 year ago. Illnesses - hiatus hernia as above. No history of rheumatic fever, diabetes, tuberculosis, or other serious illnesses. No serious injuries. Family History: father died of heart attack at age 54; he also had diabetes mellitus. Mother died with multiple myeloma at age 73. Both grandfathers are said to have died with kidney trouble. One grandmother died with jaundice, cause unknown. She has 2 sisters and 1 brother who are all living and well. Marital History: patient has been married 32 years. She had one son who was killed in the Korean War, at about age 21. Patient had 2 miscarriages after her son was born. These occurred within the first two months of pregnancy. Dental History: her teeth were in good condition up to about age 22 when she began to have cavities. Over the next 10 years she had all of her upper teeth out and an upper plate put in. She has also had 4 lower teeth extracted; no teeth have been extracted in the past 6 to 7 years. Remaining teeth have caused her little trouble. Radiation Exposure: patient worked from 3 September 1924 to 6 March 1925 at about the age of 16 painting radium on the dials and hands of watches using a brush, which she pointed with her lips. She did not notice any glowing of her skin, hair, or clothes at night; however, she did on a few occasions paint lines of radium on her face, eyebrows, and ears to see the resulting glow. This patient had no further direct radium exposure. She has had several diagnostic x-rays including barium enema, upper g.i. series, IVP , several chest films, films of the throat and skull. She also worked as an aide in a hospital at which time she would help to hold children on the x-ray table for plain films and for fluoroscopies.

Physical Examination: height 64-1/4", weight 217 lbs., BP 166/104 (supine), pulse 80 per minute and regular. A well-developed, obese, white lady who appears in good health. Skin: normal texture as was the scalp hair; body hair was unremarkable. No significant lymphadenopathy. HENT: retinal exam negative. EOM: normal. Nose: narrow nasal passages. Throat: negative. Complete edenture of the upper jaw with an upper plate. Four lower teeth missing, other teeth were in good repair. The right ear drum was blue-gray, but there was no light reflex. Chest: resonant, no pulmonary rales. Heart: regular sinus rhythm, 80 per minute, M1 greater than M2. Abdomen: obese, well-healed linear scars of the operations mentioned. The liver was palpable deep in the abdomen one to two finger breadths below the right costal margin. Spleen not felt. There is a slight tenderness of the

epigastric area. Pelvic and Rectal: not done. Extremities: no ankle edema. Prominent veins of the lower legs. Good dorsalis pedis pulses. CNS: deep tendon reflexes were physiological. No delay of the relaxation phases. Flexor plantar responses.
Lab. Findings: Urinalysis: sp. gr. 1.015, albumin neg., sugar neg., microscopic not done. Hematology: wbc 4700, differential P56, L44, rbc normocytic, corr. sed. rate 10 mm/hr., hematocrit 42 percent. Blood chemistries: alk. phos. 6.0 units, BUN 16.6 mg percent, sugar 105 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.7, alb 4.28, TG 2.42, $\alpha 1$ 0.27, $\alpha 2$ 0.49, β 0.69, γ 0.97.
X-ray Findings: skeletal series shows there is no evidence of radiation osteitis. The skull is normal and the sinuses are aerated. The heart and lungs are normal. There are degenerative changes in the dorsal spine and about both knees. Calcification is seen in the soft tissues adjacent to the left greater tuberosity on the humerus. There are wire sutures in the left side of the abdomen due to previous surgery. No other abnormalities are seen. The remaining teeth and adjacent alveolar processes show no evidence of radiation osteitis.

(01-221) Born 24 December 1892. Present Health: quite well at present. Eight years ago he had a cancer of the bladder removed. At the same time part of the right ureteral vesicle junction was removed and the right ureter was reattached to a different part of the bladder. Before this operation he had had two procedures apparently involving electrical desiccation of the bladder tumor. He then had cystoscopies about every three months; no new pathology was found. During the end of last winter, however, he noticed what appeared to be spots of dried blood in the urine. An IVP showed poor excretion of the right kidney. Six months ago the right kidney and right ureter and part of the bladder was removed. He states that a nodule on the bladder was malignant at that time. He has felt very well since. Cystoscopy one month ago was apparently negative.
Systems Review. HENT: he has had a cataract of the right eye for several years. He is unable to read with that eye but can distinguish objects and color, about 50 percent vision. There has been no progression of cataract recently. Vision of the left eye is good. He has noticed some decrease of hearing of the right ear. Nose and Throat: negative. CR: occasional left shoulder pain with strenuous exercise. No vascular disease. GI: weight has been steady at 165-170 lbs. Appetite is good, he avoids fried

foods, cucumbers, spiced food, because they cause some belching and distress. GU: see Present Health. Allergy: no known allergies. He has had penicillin, sulfur, and other drugs without reaction. Endocrine: negative. Skin: he has had depigmentation of various areas of the skin most of his life. Habits: he sleeps well. He has never smoked cigarettes, drinks alcohol very moderately. Coffee, tea, and milk consumption is moderate. He takes no medicines regularly. His hobby is golf, occasionally bowls in the wintertime. In his younger years he was more athletic. Past History: in addition to the operations mentioned, he had a hemorrhoidectomy in 1911, he had an appendectomy and reoperation for abscess formation in 1922; at the time he had a phlebitis of the left leg; this leg still continues to swell during the day and has prominent varicose veins. He has had no serious medical illnesses. No rheumatic fever, diabetes, tuberculosis. No fractures. Family History: father died of a heart attack at the age of 69; mother died at 75, causes unknown. He has two brothers and one sister, living and well. Another brother died in infancy. There was no known family history of cancer, tuberculosis, diabetes, allergy, or epilepsy. Marital History: patient's first wife died about three years ago after 34 years of marriage. They had had one daughter who is now 29 years old, and there are two grandchildren. Patient remarried in 1958. Dental History: patient had a tendency to dental decay during most of his life. He has had seven teeth removed at different periods over an approximately 15 year period. He now has an upper and lower denture with a total of seven false teeth; the remainder of his teeth have been in good condition. Radiation Exposure: worked from 1916 to 1925 with a radium company. For two of these years he was in charge of mining operations in Colorado; he had also been plant manager and in charge of production. His work was in a supervisory capacity during these nine years. He would occasionally touch some of the radiant ore in passing it from place to place, but had no consistent daily intimate handling of the material. His plant handled the ore, leaching it and concentrating it. They produced tubes, needles, and placques of the radium for use by doctors in medical work. There was a safe in his office which would contain radium material that was waiting for delivery to doctors or had been returned by doctors. This radium which might amount from 100 mg to 1 g at a time was contained in lead parcels. He had also handled MsTh in this work, but only in the same intermittent way. He had never noticed any consistent glowing of his clothes or hair at night. He stated that he would occasionally see glowing

spots on his clothes, but he believed that these were due to spots of ZnS which had come from the application division of the plant. In the application division powdered ZnS was used, and the ZnS itself would glow if exposed to light. His secretary who had used, and was responsible for, the radium in the safe in his office, apparently died about 12 to 14 years after exposure, apparently of radium poisoning. He was said to have had more white blood cells than red blood cells.

Physical Examination: a well-developed, well-nourished, healthy-appearing man, BP 178/96, pulse 60 per minute. Skin was tanned, there were several depigmented areas. There was one dilated venule of the right chest. No lymphadenopathy. HENT: there was a central cataract of the right eye. Left retina showed some narrowing of arterioles. Nose: negative. Throat: negative except that the right tonsil appeared larger than the left. His teeth appeared in good condition except for the dentures containing seven false teeth. Thyroid was not felt. Lungs: negative. Heart: sounds were distant. Regular sinus rhythm 60 per minute. PMI was within the left midclavicular line. Abdomen: liver was felt one finger-breadth below the right costal margin; the spleen was not felt. Well-healed scars of the operations mentioned were present. Genitalia: there were depigmentations of the skin of the penis; there was a large, soft, fluctuant mass of the right testicular area (this mass has been present since his last operation). Rectal: there was some firmness of the tissues to either side of the prostate gland. Extremities: left leg was larger than the right, contained several prominent dilated varicose veins. Measurement of the right leg was 15-3/4", of the left leg 17-1/4" taken about 4" below the bottom part of the patella. The dorsalis pedis pulses were good. Central nervous system examination was unremarkable. Plantar reflexes were flexor.

Lab. Findings: Urinalysis: sp. gr.1.010, albumin neg., sugar neg., occ wbc/HPF. Hematology: wbc 7100, differential P60, L40, rbc normocytic, corr. sed. rate 24 mm/hr., hematocrit 43 percent. Blood chemistries: alk. phos. 5.6 units, BUN 23 mg percent, sugar 125 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.5, alb 4.60, TG 1.90, $\alpha 1$ 0.07, $\alpha 2$ 0.28, β 0.78, γ 0.77.

X-ray Findings: skeletal series fails to show any evidence of radium poisoning. Incidental findings are: the presence of several radon seeds in the region of the bladder, calcification in the soft tissues of both thighs, probably due to calcified thrombi, small areas of increased bone density in the proximal ends of both tibiae which are probably representing

innocent bone islands, minimal degenerative cystic changes in the heads of the middle phalanges of several fingers. The remaining teeth show no evidence of paridental absorption, and the alveolar processes, as far as they are visible show no evidence of radiation necrosis.

(01-225) Born 30 May 1906. Present Health: after a fall in 1956 patient began to have severe low back pain with radiation into the left leg, lateral aspect of the thigh, and posterior aspect of the lower leg, also from the heel to the toes. There was numbness and"pins and needles"in the same areas. A diagnosis of herniated intervertebral disk was made, and a laminectomy was performed. She does not feel that she had much relief of symptoms after the operation, feels that the symptoms have been progressive in intensity since that time. X-rays have apparently shown "soft bones" of the spine, and she has been treated for this with various medicines including nilevar. The back pain tends to be worse in the morning, better as she walks around during the day. Aside from these symptoms, she feels in fairly good health. Systems Review: HENT: occasional occipital throbbing headache. She wears glasses. No ear, nose, or throat symptoms. A goiter appeared in 1941; she had symptoms of something sticking when she swallowed which was better after a thyroidectomy. She took thyroid medicines for two years after the operation, none now. BMR's have apparently been normal. No symptoms of hyperthyroid disease. Studies of serum calcium and phosphorus are not known. CV: negative. GI: appetite good. She has had a weight gain in the past six months from 128 to 135 lbs. She has chronic constipation, no other GI symptoms. GU: negative, except for a kidney infection at the time of her back operation. Catamenia: after a hysterectomy in 1954 for fibroid tumors following symptoms of abdominal swelling and back pain, she has had no bleeding. Allergy: no allergies known. Skin: patient notes an itchy skin after getting out of a hot bath for some years. This occurs only in the summer. She has been in the habit of taking a cortisone (? ACTH) tablet for this itchiness whenever it occurs. She bathes daily in the summertime. NM: see above. No known fractures. She has had a bursitis of the left shoulder treated with medicines. Habits: cigarettes rare, alcohol rare, coffee, tea, and milk moderate. She follows a balanced diet. Takes aspirin regularly for relief of the back pain. Past History: in addition to the operations mentioned above, she has had her tonsils removed twice. The only other hospitalization was for diagnostic study of her back six months ago. No other serious illnesses. Family History: no history

of heart or kidney disease, of tuberculosis, diabetes, allergy, or epilepsy in the family. She states that her mother died at 28, when patient was 3 years old, of a carcinoma. She had three sisters, one of whom died at 19 with a cancer, one at 35 of a cancer of the rectum, and one died at 40 apparently with a metastatic cancer from the cervix or uterus. One brother died at 53 of metastatic cancer, said to start from a tumor of the jaw. Her father died at 89, cause unknown. Marital History: patient has been married for 33 years. She has had no children, had one miscarriage when she was about two months pregnant. Dental History: remembers having cavities during her early life. By the age of 29, she had an upper partial plate with six artificial teeth. She then had several extractions through the years, until in 1954, all of her teeth began to become more carious. All the lower teeth were extracted, and she has had full dentures since. Radiation Exposure: patient worked from 28 September 1931 to 23 November 1931 using a machine to transfer radium to a jelly pad, the clock dials were then stamped onto this jelly pad. Bare hands were used in the process; she often saw glowing of her hands, arms, and clothes at night. She actually handled the radium off and on for three years, either working with it or in the same room. She was about 25 years old at the time.

Physical Examination: a well-developed, well-nourished white lady appearing in good health, weight 138 lbs., height 61-1/2", BP 134/90, pulse 76 per minute. Skin: negative. No significant lymphadenopathy. Hair slightly coarse in texture, body hair appeared normal. HENT: eyes, ears, nose, and throat negative. Tonsils absent. There was a well-healed thyroidectomy scar. Chest: no abnormalities noted. Heart: regular sinus rhythm, 76 per minute with a rare PVB, A2 greater than P2, M2 greater than M1. Abdomen: the liver and spleen were not felt. No masses were palpated. There was a well-healed linear suprapubic midline scar. There was no costovertebral angle tenderness; there was a mild tenderness of the vertebrae from the 10th thoracic down through the first sacral. Well-healed laminectomy scars were present. Pelvic and Rectal: not done. Extremities: no ankle edema. Left leg appeared slightly puffy. Dorsalis pedis pulses were good. CNS: deep tendon reflexes were normal in the upper extremities; the knee jerks and ankle jerks were 2-plus, symmetrical and brisk; flexor plantar responses bilaterally. There was a minimal decrease in sensation to pinprick of the lateral aspect of the left lower leg. Straight leg raising was limited to 15°on the left, 20° on the right.

Lab. Findings: Urinalysis: not done. Hematology: wbc 5600, differential

P70, L30, rbc normocytic, corr. sed. rate 1 mm/hr., hematocrit 44 percent. Blood chemistries: alk. phos. 9.5 units, BUN 17 mg percent, sugar 104 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.6, alb 4.90, TG 2.70, $\alpha 1$ 0.37, $\alpha 2$ 0.58, β 0.68, γ 1.07.
X-ray Findings: skeletal series fails to show any evidence of radiation osteitis.

(01-226) Born 1 September 1915. Present Health: good. Her main problem is that she is overweight and does not seem to be able to lose weight. She works regularly, feels well.
Systems Review. HENT: eyes - does not wear glasses. Ears: ruptured eardrum when a child from infection. Nose: negative. Throat: tonsillectomy in 1944. No history of goiter. CV: patient feels occasional fast beating of the heart when overtired. GI: appetite very good. No GI symptoms. GU: had dysuria at one time about eight years ago, rarely since. Catamenia: periods are regular every 28 days, last about 4-5 days, no symptoms at the time of periods. She had an infected tube about 14 years ago with a discharge and back pain which was better after treatment (type unknown). Allergy: none known. Patient has had penicillin. NM: no fractures except for the tip of the 4th digit of the right hand which was caught in a car door two to three months ago. Habits: she rarely smokes cigarettes, rarely takes alcoholic beverages. She drinks about seven cups of coffee a day. She occasionally takes medicines to help reduce. She has gained about 20 lbs. in the past six years to her present weight of about 228 lbs. Past History: operations - T and A as above. She has never been in the hospital, has had no serious illnesses or injuries. Family History: mother died at age 61 with a heart attack; father died at age 51 with pneumonia. One brother died at age 35 with leukemia; she has one sister who is living and well. There were apparently five other siblings, whose history is unknown and who she believes died in Italy. No known history of tuberculosis, diabetes, allergy, or epilepsy in the family. Marital History: never married, no pregnancies. Dental History: occasional cavities all her life and occasional extractions. She has all of her upper teeth except one; she has eight of her own lower teeth. No dentures. The remaining teeth contain some unfilled cavities. Radiation Exposure: she worked in 1927 from 22 February 1927 to 21 July 1927 at the age of 11 years. She painted radium on the dials of watches with a brush which was dipped into water and then into the radium. The

brushes were pointed with her fingers, and she never used her lips to point them, she says. She does not remember any glowing of skin, hair, or clothing at night.

Physical Examination: weight 224 lbs., height 62-3/4", BP 146/94 (supine, right arm), pulse 84 per minute and regular. She appears to be in good health. Skin was normal. Hair was of normal texture. HENT: retinae appear normal, extraocular movements normal. Nose and Throat: negative. The edges of the lower teeth appeared eroded; the teeth were in fairly good repair; one upper t th on the right side was missing, four lower teeth were missing bilaterally. Thyroid gland was just palpable. Chest: expansion good, breath sounds distant and clear. Heart: regular sinus rhythm 84 per minute, distant sounds. Breasts: appeared normal to inspection and palpation. Abdomen: obese. Liver and spleen were not felt. There was erythema of the intertriginous area of an early panniculus formation. Pelvic and Rectal: not done. There was no significant lymphadenopathy. Extremities: circular scar formation over left patella area, no ankle edema, good dorsalis pedis pulses. The hands appeared normal. CNS: deep tendon reflexes present, equal and symmetrical, flexor plantar responses.

Lab. Findings: Urinalysis: sp. gr. 1.030, albumin neg., sugar neg., many wbc, many epith, occ rbc/HPF. Hematology: wbc 6200, differential P65, L35, rbc normocytic, corr. sed. rate 1 mm/hr., hematocrit 41 percent. Blood chemistries: alk. phos. 7.4 units, BUN 19.4 mg percent, sugar 119 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.0, alb 4.26, TG 2.74, $\alpha 1$ 0.32, $\alpha 2$ 0.57, β 0.77, γ 1.08.

X-ray Findings: skeletal series shows there is no evidence of radiation osteitis. The following abnormalities are seen: there is an old ununited fracture of the distal phalanx of the fourth finger on the right; there is thickening of the internal table of the frontal bone, so-called hyperostosis frontalis interna. This is of no significance. The heart and lungs are normal. There is a calcific density superimposed on the 11th dorsal vertebra. Doubt that this is of any significance. Dental films fail to show any evidence of radiation damage.

(01-227) Born 26 August 1908. Present Health: no recent illnesses, considers herself to be in good health, except that she is going through the change of life.

Systems Review. Head: no headaches. Wears glasses for close work. Ears: hearing is good; has had no ear infections. Nose: sense of smell good. See Past History for nasal surgery. Mouth: no soreness of tongue or mouth. No dysphagia, no sore throats. Neck: to her knowledge has never had a goiter. In 1940 was told she had a BMR of -16 and took thyroid for several years. Breasts: no known masses or infections. CR: had pneumonia in 1933. No chest pain, no cough, no hemoptysis, no dyspnea on exertion, sleeps lying flat, no ankle edema. No knowledge of rheumatic fever, heart murmurs, or high blood pressure. GI: appetite is good; weight remains constant. She has no indigestion or gas. Has no food dyscrasias. She has never had jaundice. Her bowels move once a day without laxatives. No rectal bleeding or hemorrhoids. GU: no known infections of the kidneys or bladder. No nocturia, dysuria, etc. Catamenia: menarche at age 13 or 14. No pregnancies. At present, she is having her menstrual period; the one prior to this was in May, and the one prior to that was three months ago. She has had no hot flashes, but she says she is going through the change. Neurological: no epilepsy or seizures. No weakness of extremities. Skin: negative. Extremities: develops aching of her left knee off and on, and notices that it occasionally cracks when she moves it. No known varicose veins. Psychological: she says she is easily depressed, cries occasionally, and feels blue, and when tensions build up she takes these out by walking a lot. Habits: no tobacco, occasional alcohol. Takes an occasional pill of some kind for nervousness. Past History: operations - 1955 had plastic surgery done on her nose and upper lip. This was done because of frequent episodes of epistaxis which had occurred ever since childhood. She has had her nose cauterized numerous times, and since the operation has had no episodes of epistaxis. Serious illnesses: none. Just the usual childhood diseases. Allergies: none. Family History: father died at the age of 54 of heart disease; mother died at the age of 79 of old age and complications following a fracture of her arm. One brother died at the age of 19, during the 1st World War, of flu and tuberculosis. A sister died at the age of 45 of chronic colitis. This sounds as though it were ulcerative colitis. A brother died at the age of 54 of diabetes and tuberculosis. A sister died at the age of 46; she was a suicide. One living brother who had tuberculosis, but is now in good health, and one living sister who recently had a cholecystectomy and a hysterectomy. Marital History: has never been married. Dental History: she has all of her own teeth, with the exception of one wisdom tooth. She sees her dentist two

times a year and has no trouble. Radiation Exposure: no exposure to radioactive substances until about 1950 when she started the job of putting dials and hands on watch movements. At this time the company was well alerted to the dangers involved, and she had routine blood tests, breath tests, etc. She never glowed in the dark. Never put materials in her mouth, and probably had a very minimal exposure. She started working in 1933.
Physical Examination: a well-developed and nourished 50-year-old white female who appears to be in excellent health, weight 140.5 lbs., height 62-1/4", BP 132/74, pulse 68. Head: eyes - pupils equal, react to light and accommodation, extraocular movements normal, fundi negative. Ears: eardrums intact, hearing good. Nose: no scars seen, but there is some slight distortion of her upper lip as a result of the previously mentioned nasal surgery. Mouth: throat benign; teeth present and in excellent state of repair. Neck: small thyroid, carotids both pulsating. Breasts: large, pendulous; no fixed masses or tenderness. Lungs: good breath sounds, no rales. Heart: not enlarged. Rhythm regular, rate moderate. Good sounds, no murmurs. Abdomen: no scars, flat, no organs, masses, or tenderness. Rectal and Pelvic: not done. Extremities: good pedal pulsations, no edema, no clubbing, good femoral pulses. Neurological: within normal limits. Skin: no abnormalities. Diagnosis: no disease found.
Lab. Findings: Urinalysis: patient menstruating, no specimen. Hematology: wbc 7600, differential P65, L33, E2, rbc normocytic, corr. sed. rate 20 mm/hr., hematocrit 39 percent. Blood chemistries: alk. phos. 4.5 units, BUN 27.6 mg percent, sugar 136 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.8, alb 4.8, TG 2.0, $\alpha 1$ 0.21, $\alpha 2$ 0.34, β 0.56, γ 0.89.
X-ray Findings: skeletal series fails to show any pathology. There are some localized areas of decalcification in the temple bones, most likely representing venous lakes. Dental films show no evidence of periodontal disease. The alveolar processes appear normal. The teeth show many fillings but show no defects.

(01-228) Born 6 March 1906. Present Health: physically, she feels that she is in good health; she does, however, see a psychiatrist every five to six weeks. This is in connection with an apparently psychotic episode that arose in 1949.
Systems Review. Head: rare headaches now that are controlled with aspirin. Eyes: no disease or blackouts, is farsighted. Ears: hearing good, no tinnitus. Nose: her sense of smell is good. Will get slight epistaxis with a head cold. Mouth: rare sore throats. No dysphagia. No soreness

of the mouth or tongue. Neck: no known goiter, but she says in the past because of her obesity, it has been thought she may have had a slow thyroid. Breasts: negative. CR: she says that on occasion her psychiatrist will give her an injection for ankle edema. She is not on a low salt diet, and says her ankles are always small in the morning when she gets out of bed. Has no dyspnea on exertion. No known pneumonia or hemoptysis. No chest pain, no history of rheumatic fever, high blood pressure, or cardiac murmurs. GI: appetite very good. At the moment her weight is more or less constant. She does not have nausea or vomiting. In 1918 she had a brief episode of jaundice following a vaccination. Bowels move ordinarily once a day, rarely uses laxatives. GU: in 1941 she had an episode of dysuria and was treated for this with some sort of blue medication. Has occasional nocturia one time, and no dysuria now. Catamenia: menarche at age 13. Regular periods every 28 days until 1955 when she had her hysterectomy and has had no bleeding since. No dyspareunia or postcoital bleeding. Extremities: no known varicose veins or joint pathology. Neuropsychiatric: in 1949 the patient had some sort of an episode which she describes as feeling that her head was inflated like a tire with a hole in it. She had a feeling as though her head were on the skids and the pain was bouncing off. She was having a constant smell of ammonia and a number of other bizarre symptoms. She was never hospitalized and says that the symptoms have all improved now. Habits: smokes ten cigarettes a day, has an occasional drink. The only medication she takes is an occasional injection which sounds as though it is a diuretic. Past History: operations - 1929 tonsillectomy, 1955 hysterectomy, appendectomy, and bladder repair which was done for uterine fibroids and excessive menstrual bleeding. Serious illnesses: none. Allergies: none. Family History: father living, age 81, in good health; mother died at age 67. She had had gallbladder disease and adhesions, and there is a question of whether the terminal episode was a carcinoma of some sort since she had had radium treatments. A sister died at the age of 43, and she had been receiving radium treatments for a carcinoma of the "vagina". Two sisters and one brother are living and well. Maternal grandmother had diabetes. Marital History: is married and has two children, a girl age 27, and a boy age 26, both of whom are living and well. Dental History: all of her teeth had been removed by 1941. She says this was due to a fragile jaw bone. She wears upper and lower dentures; however, at the moment her lower dentures are broken. Radiation Exposure:

from 15 March 1925 to 25 May 1926 worked painting clock dials. She does not recall having put the brush in her mouth to sharpen the tip, and she does not recall ever having noted her hair, teeth, or hands glowing in the dark.

Physical Examination: an obese, blond, very garrulous, circumstantial woman who appeared to be in good health, weight 204 lbs., height 64", BP 148/86, pulse 64. Head: eyes - pupils equal, react to light and accommodation, extraocular movements normal, fundi within normal limits. Ears: ear drums intact, hearing acute. Nose: negative. Mouth: no teeth. Upper denture present. Tongue and Throat: negative. Neck: no enlarged lymph nodes or thyroid. Carotids both pulsating. Breasts: very large; no masses or tenderness. Lungs: good breath sounds, no rales. Heart: not enlarged, tones rather distant. Has a grade 2, harsh, apical systolic murmur, A2 louder than P2. Abdomen: very obese, old well-healed midline scar between navel and pubis. No organs, masses, or tenderness. Pelvic and Rectal: not done. Extremities: no edema, no varicose veins. Joints appear normal. Neurological: within normal limits. Skin: within normal limits: Diagnosis: exogenous obesity.

Lab. Findings: Urinalysis: sp. gr. 1.020, albumin neg., sugar neg., 0-1 wbc/HPF, occ rbc/HPF, 10-12 epith/HPF. Hematology: wbc 10,000, differential P66, L27, E3, M4, rbc normocytic, corr. sed. rate 25 mm/hr., hematocrit 44 percent. Blood chemistries: alk. phos. 3.3 units, BUN 16 mg percent, sugar 88 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.2, alb 4.8, TG 2.4, $\alpha 1$ 0.28, $\alpha 2$ 0.55, β 0.76, γ 0.79.

X-ray Findings: skeletal series fails to show any evidence of radium bone changes. Incidental findings are: minimal soft tissue calcification close to the greater tuberosity of the right humerus (bursitis), areas of increased density in both buttocks, most likely representing calcification in the region of previous injections.

(01-229) Born 15 November 1903. Present Health: patient considers herself to be in good health.

Systems Review: has occasional headaches which she thinks are probably due to sinus trouble. No fainting spells. No fits, no epilepsy. Eyes: wears

glasses at all times. Ears: hearing is good, no ear infections, occasional tinnitus. Nose: sense of smell is good, no epistaxis. Mouth: no soreness of mouth or tongue, occasional dysphagia which she feels is due to a goiter. Neck: she has noticed swelling of her goiter since about last October. She says she has lost about 25 lbs. and is considerably more irritable than she used to be. Her legs get tired when she goes up and down stairs. She is uncertain as to whether her skin is more fine or coarse textured than it has been. She likes cold weather. She sleeps with her husband and has a positive blanket sign. Feels she sweats a great deal. As compared to several years ago, she feels she is more constipated now. Breasts: no masses observed. CR: tends to get ankle edema at the end of most every day. For the past year has had infrequent brief episodes of substernal tightness which do not worry her and do not seem to be associated either with food or with exercise. She says she has been known to have high blood pressure for several years but that it is normal now. She is a moderate salt-eater. No known rheumatic fever or heart murmurs. No shortness of breath, pneumonia, or hemoptysis. GI: appetite fairly good, she craves sweets. In 1953 she had an episode of epigastric pain. A GI series, she says, showed an ulcer. Takes some green pills intermittently for this. She is on no diet. To her knowledge has never had a bloody bowel movement. Her bowels move once a day; she takes no laxatives. Has never had yellow jaundice. GU: no known infections of the kidneys or the bladder, no nocturia or dysuria. Catamenia: menarche occurred at age 16, has had no periods since 1937 following the bilateral oophorectomy. She had some hot flashes during that time. There has been no vaginal discharge,

pruritus, or vaginal bleeding. Extremities: is beginning to notice some stiffness of joints of her fingers when the weather is bad. No known varicosities or intermittent claudication. Neurological: within normal limits. Habits: about twenty cigarettes a day, alcohol occasionally. For ten years has been taking a very occasional pill for an ulcer. Sleeps about five hours a night. Past History: operations - at age 37 had a bilateral oophorectomy and appendectomy. This was done because, she thinks, of a ruptured right ovary. She has had no periods since that time. Serious illnesses: none. Allergies: none. Family History: father died at age 54 in an accident. Mother died at age 78, four years after a hip fracture. Has two brothers and four sisters, all of whom are living and well. Marital History: is married and has three children, ages 31, 28, 25, all of whom are living and well. Dental History: had all of her upper teeth extracted by age 45, and all of her lower teeth were extracted by age 40. She says this was because her gums were receding. Radiation Exposure: painted watch dials from 28 August 1923 to 12 September 1923. She remembers being taught to lick the brush with her tongue and she recalls that her hair glowed at night.

Physical Examination: height 60-3/4", weight 130.5 lbs., BP 150/78, pulse 84. Patient is a small, alert, pale, prominent-eyed 55-year-old woman who looks to be in good health. Eyes: pupils equal, react to light and accommodation, extraocular movements normal. A suggestive lidlag, fundi negative, a very faint arcus senilis. Slight stare. Ears: drums intact, hearing acute. Nose: negative. Mouth: upper and lower plates. Throat: benign. Neck: has a 3-plus smooth symmetrical enlarged thyroid which is slightly greater in the right lobe. Carotids both pulsating. Breasts: no masses or tenderness. Lungs: good resonances, rather coarse breath sounds throughout that clear with coughing. Heart: not enlarged. Grade 1-2 soft blowing apical systolic murmur. Abdomen: slightly obese. Has thin midline superpubic scar that extends to the navel. No organs, masses, or tenderness. Rectal and Pelvic: not done. Extremities: moist hands, good peripheral pulsations, no edema. Joints appear normal. Neurological: no tremor, but deep tendon reflexes active and equal. Note above-mentioned suggestive lidlag. Skin: pale, fine-textured. Diagnosis: question hyperthyroid.

Lab. Findings: Urinalysis: sp. gr. 1.011, albumin neg., sugar 1+, 0-2 wbc/HPF, 2-3 epithelial cells/HPF, 2-3 rbc/HPF. Hematology: wbc 6400, differential P60, L36, E1, M3, rbc normocytic, corr. sed. rate 23 mm/hr., hematocrit 42 percent. Blood chemistries: alk. phos. 4.0 units, BUN 21

mg percent, sugar 218 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.8, alb 4.5, TG 2.3, α1 0.16, α2 0.59, β 0.73, γ 0.77. Protein-Bound Iodine: PBI 5.5 mcg percent, TI 5.7 mcg percent.
X-ray Findings: skeletal series shows poorly defined almost gaunt areas of decalcification in the posterior parietal regions most likely on the right side. They are suggestive of radium poisoning. The films of the upper ends of the tibia and the fibula and of the lower ends of the tibia and the fibula show slight osteopetrosis which may or may not be connected with the radium poisoning. Other incidental findings are some degenerative changes about several of the interphalangeal joints and the presence of a minimal amount of calcification in the soft tissues close to the greater tuberosity on the right joints.

(01-230) Born 5 September 1913. Present Health: for the past four years has had recurrent difficulty with tightness in her throat. This is not a sore throat; it does not interfere with her swallowing. She has been seen by numerous doctors, and they seem to feel that it is nerves. Also four years ago she had a BMR done which was -23. Because of this and a low blood pressure she was put on 3 grains of thyroid a day. She says that this gave her extreme nervousness. Four, and again two years ago, she was told not to take thyroid any more, so she has not taken any thyroid for the past three years.
Systems Review: rare headaches, no dizziness or fainting spells. Recently she has been seeing an ophthalmologist because of what she calls allergic troubles of the lid of her left eye. She does not wear glasses, but says she needs reading glasses. Ears: hearing is good, no ear infections. Nose: good sense of smell. No epistaxis. Mouth: no soreness. No dysphagia. Neck: see above. Breasts: no history of tumors or infections. CR: see below for tuberculosis. No ankle edema. No dyspnea on exertion. No chest pain. No known history of high blood pressure, of rheumatic fever, or of heart murmurs. GI: appetite good, no food dyscrasias, occasional gas. Bowels move irregularly, sometimes going as long as three or four days. The only laxative she takes is fruit juice. She does not recall jaundice. GU: no infections of the kidneys or the bladder. No nocturia and no dysuria. Catamenia: menarche at age 11. No hot flashes (see below for hysterectomy). Skin: see below. Extremities: no rheumatism, arthritis, or varicose veins. Habits: no tobacco, occasional alcohol. Taking no medications at the present time. Past History: operations - tonsillectomy

at age 12. In 1947 had a partial hysterectomy which was done because of vaginal bleeding. She was told she was not to have any more periods but she says that at monthly intervals she has had a slight show. Serious illnesses: in 1933 she had pleurisy and spent six months in a sanatorium, presumably for tuberculosis. She received pneumothorax to the left side during this time. Allergies: no asthma. Says she is allergic to grass and during the grass season does a lot of sneezing and has a stuffed head, but this is not every year. Has taken both desensitization injections and antihistamines. She gets rare cases of urticaria, the allergy of which is unknown. Family History: father is living, age 70, has had a gallbladder operation; mother died at age 56 of asthma. A brother was killed in the 2nd World War at age 21. A sister died at age 2 of pneumonia. No other siblings. Marital History: is married, and has one daughter, age 18, who is in good health. Dental History: she has all of her own teeth which are in a state of good repair. She last saw her dentist six months ago. Radiation Exposure: she is very unclear about this, and, in fact, had completely forgotten that she ever worked with radioactive materials. She worked from 4 October 1927 to 13 February 1928 at the age of 14 painting watch dials, but she does not remember putting the brush in her mouth, and she does not recall ever glowing in the dark.

Physical Examination: a small, active, very garrulous, healthy-looking, 45-year-old woman who is in no distress, weight 126.5 lbs., height 60", BP 114/74, pulse 72. Head: eyes - pupils equal, react to light and accommodation, extraocular movements normal, fundi within normal limits. Ears: drums intact, hearing excellent. Nose: negative. Neck: small thyroid but right over the area of the thyroid isthmus, there is a 1 cm movable, nontender nodule. Carotids both pulsating. Breasts: no masses. Lungs: good breath sounds, no rales. Heart: not enlarged. Tones good, rhythm regular, no murmurs. Abdomen: scar of old hysterectomy well healed. No organs, masses, or tenderness noted. Good femoral pulsations. Extremities: no joint pathology, good pedal pulses, no clubbing of fingers or toes, no edema. Skin: one ecchymotic area of right calf; this is probably due to trauma. Neurological: within normal limits. Lymphatics: no enlarged nodes. Diagnoses: arrested tuberculosis, pulmonary; question thyroid nodule, question thyroglossal cyst.

Lab. Findings: inadvertently omitted.

X-ray Findings: skeletal series shows no bony abnormality. The teeth show no defects and there is no evidence of peridental disease. Incidental

findings are: evidence of old pleural disease on the left side with obliteration of the left costophrenic angle. Some scarring is seen in the left apex and infraclavicular area consistent with tuberculosis in the past. Activity certainly cannot be ruled out from these films.

(01-231) Born 15 June 1910. Present Health: excellent at the present moment.
Systems Review. Head: headaches only from eating chocolate. Eyes: requires bifocals, otherwise no abnormalities. Ears: no infections. Says she is a wax collector and has to have her ears blown out periodically. Hearing is good. Nose: good sense of smell, no epistaxis. Mouth: no sore tongue, no dysphagia. Neck: no known goiter. Breasts: no masses or tenderness. CR: no pneumonia or hemoptysis. No ankle edema, no chest pain, very minimal dyspnea on exertion, sleeps on one pillow. Says that in the past there has been some question as to whether or not she had high blood pressure. GI: her appetite is good, her weight remains constant. Only food dyscrasia is chocolate. She has no indigestion or gas. Never had yellow jaundice. Moves her bowels once a day, does not take laxatives, and has never had blood in her stools. GU: no known infections of her kidneys or bladder. No nocturia, no dysuria. Catamenia: menarche occurred at the age of 14. Her last menstrual period was 24 June; she says her periods are becoming irregular and scanty, and has had questionable hot flashes. Extremities: three years ago had an acute bursitis of her left shoulder, but otherwise has had no rheumatism, arthritis, or varicose veins. Neuropsychiatric: within normal limits. No skin diseases. Habits: cigarettes, 20 a day; rare alcohol. No medication. Averages eight hours sleep per night. Past History: operations - she thinks that possibly as a child she had an operation on her neck for an abscess. Serious illnesses: none. Allergies: gets violent headaches from eating chocolate. Family History: father, living, age 79, in good health; mother died at the age of 80, apparently of old age. Two siblings died in their infancy. Two sisters and two brothers living and well. Marital History: is married but has no children. She feels that this apparently was due, or so she was told, to a bad ovary. Dental History: has a full upper plate, and eight lower teeth still remaining. She says she always had soft teeth, even though she has religiously seen her dentist twice a year since the age of 14. Radiation Exposure: from 31 January 1930 to 14 September 1931 she worked on clock dials, not as a painter, but just in putting the dry, painted hands onto

the watch face. She does not recall that her hands, teeth, or hair glowed in the dark.

Physical Examination: a small, plump, spry, bright-eyed, well-developed, healthy-looking 49-year-old woman in no distress, height 58", weight 124 lbs., BP 134/80, pulse 88. Eyes: pupils equal, react to light and accommodation, extraocular movements normal, fundi within normal limits. Ears: drums intact, hearing acute. Nose: negative. Mouth: upper plate, eight remaining lower teeth in fair state of repair. Throat: negative. Tongue well papillated. Neck: carotids pulsating, no enlarged nodes, small thyroid. Breasts: small, no masses, no tenderness. Lungs: resonant, good breath sounds, no rales, Heart: not enlarged. Tones clear, rhythm regular, no murmurs, A2 louder than P2. Abdomen: no scars, not distended. On deep inspiration has a firm, sharp liver edge which comes down about 2 cm below the right costal margin in the midclavicular line. Good femoral pulses. Pelvic and Rectal: not done. Extremities: good pedal pulses, no edema, no varicose veins. Neurological: cranial nerves intact, deep tendon reflexes within normal limits, no sensory deficits. Skin: negative. Diagnosis: no disease.

Lab. Findings: Urinalysis: sp. gr. 1.025, albumin neg., sugar neg., 20-25 epith/HPF, 2-4 wbc/HPF, little bacteria. Hematology: wbc 9000, differential P58, L50, E1, M1, rbc marked hypochromia, corr. sed. rate 11 mm/hr., hematocrit 33 percent. Blood chemistries: alk. phos. 5.1 units, BUN 12.2 mg percent, sugar 103 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.9, alb 4.5, TG 2.4, $\alpha 1$ 0.32, $\alpha 2$ 0.62, β 0.71, γ 0.79.

X-ray Findings: skeletal series shows there is no evidence of radium poisoning. Incidental finding is minimal. Calcification of the soft tissues of the left shoulder (bursitis). Dental films of the remaining teeth shows numerous repaired cavities. The alveolar ridge of the mandible and maxilla is normal and no evidence of radium poisoning is seen.

(01-232) Born 4 May 1908. Present Health: in the past six months patient has begun to feel in fairly good health after nearly 10 years of various illnesses and operations. Nearly 10 years ago she sustained a lifting injury of the back so that she had the following operations and procedures: 1951, laminectomy and removal of intervertebral disk; in 1952 a second disk was removed and a fusion operation performed; during investigation because of continued symptoms in May 1953 a lesion of the chest was seen on a routine x-ray. A segmental lung resection on the right side was done; a

tuberculoma was discovered and removed. Osteoporosis of the vertebra was seen by x-ray. She had also sustained a break of the fusion done at the second operation in a fall four months following that operation. Because of the osteoporosis she was treated in a steel brace on her back instead of refusion. Intercostal neuralgia developed, as well as muscle atrophy and winging of the right scapula. A separated rib was discovered; this was removed surgically. Intercostal neurectomy was done at the same time. Some improvement was noted. In January 1957 she was involved in an auto accident, sustained a whip-lash injury which caused further increase of her symptoms. She was in a Thomas collar for 11 months at that time. In July 1958 a stabilization operation was done. Staph infection in three areas occurred postoperatively. She gradually began to notice good improvement of her symptoms and in the use of her right arm.

Systems Review. HENT: prominence of the eyes decreased somewhat after treatment of the hyperthyroidism, but the eyes never receded entirely to normal. She states she occasionally had diplopia without her glasses. Ears, Nose, and Throat: negative. Thyroid (see above). CV: see above. Respiratory: see above. GI: appetite is good at present with no food intolerances, or other GI symptoms. GU: see above, no GU symptoms at present. Catamenia: no periods for 2-1/2 years; they had been regular. Allergy: patient had hives after diodrast. Morphine leads to marked respiratory depression. Patient received one eight-year course of bicillin for treatment of her rheumatic heart disease. NM: no known spontaneous fractures. Past History: about the age of 18 she began to have exophthalmos and symptoms of hyperthyroidism; she was treated for a year with radium water (see below) with some improvement. After recurrence of symptoms a thyroidectomy was performed in 1927. Because of fears of a second recurrence she had two series of x-ray treatments to the thyroid gland six weeks apart in 1940. These treatments were followed by a severe myxedema, with gradual improvement on thyroid extract. At present, she takes one grain of thyroid per day. A radioactive iodine uptake in 1946 was said to be normal. At about age 22 she apparently had a first episode of acute glomerulonephritis. Another episode occurred in 1940, ten years later. She had hematuria both times. These episodes occurred about a month after a "strep" throat. In 1947 a third attack occurred under similar circumstances. By 1949 she had had about ten years of severe hypertension with pressures in the area of 240/110-120. The left kidney was discovered to by hydronephrotic and nonfunctioning. It was removed. This was followed

by a gradual drop in her blood pressure. At about the age of 40, a cholecystectomy was performed at which time an engorged liver was found. It was felt that she had congestive heart failure on the basis of rheumatic heart disease and has had digitalis off and on since that time. She had a questionable episode of rheumatic fever at age 14. about age 42, she was hospitalized for an attack of congestive heart failure, treated for six weeks on low sodium diet, digitalis, and other measures. About age 46 she had a perirenal abscess on the right. Family History: father died at age 62 in an auto accident; mother is living and well at age 75. Maternal grandmother died at age 52 of Bright's disease. A first cousin and a nephew have diabetes. One aunt died with hyperthyroidism. She has one brother and one sister who are living and well. No history of carcinoma or tuberculosis in the family. Marital History: patient was married in 1935; her husband died in 1936 with influenza, also had tuberculosis.. No children, no miscarriages. Dental History: teeth have always required dental attention for cavities and she has had a dental abscess. She has had eight extractions at different times, has a permanent upper bridge with two teeth. Radiation Exposure: this patient was treated in 1926 for one year with radium water for hyperthyroidism. The treatment consisted of drinking one quart of radium water per day for 9-10 months, concentration not known.

Physical Examination: a well-developed and nourished woman who did not appear to be in good health, weight 124 lbs., height 65-1/4", BP 148/90, pulse 80 per minute. Skin was fine in texture, warm; patient was perspiring profusely. Hair normal texture. No significant lymphadenopathy. HENT: exophthalmos was present. Retinal exam revealed some tortuosity and narrowing of the arterioles with minimal AV nicking. An old exudate was seen in the left fundus. Ears, Nose, and Throat: negative. Well-healed thyroidectomy scar of the neck. Chest: right thoracotomy and drain scars. Normal resonance and breath sounds on the right, somewhat diminished breath sounds on the left especially at the apex. Heart: firm apical impulses with PMI within the left midclavicular line. Systolic thrill felt at the apex. A2 greater than P2, M1 greater than M2, split first sound. There was a well-healed left nephrectomy scar and well-healed laminectomy scars. Abdomen: liver just palpable under the right costal margin, spleen not felt. There was a well-healed cholecystectomy scar. Pelvic and Rectal: not done. Extremities: linear scars over the right tibia and the lateral upper right leg. No ankle edema. Good dorsalis

pedis pulses. CNS: 1-plus deep tendon reflexes of the upper extremities, absent knee jerk and ankle jerk on the left, minimal knee and ankle jerk on the right. Ambiguous plantar responses.
Lab. Findings: Urinalysis: not done. Hematology: wbc 7700, differential P69, L31, rbc normocytic, corr. sed. rate 1 mm/hr., hematocrit 44 percent. Blood chemistries: alk. phos. 6.2 units, BUN 21 mg percent, sugar 101 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.8, alb 5.52, TG 2.28, $\alpha 1$ 0.33, $\alpha 2$ 0.42, β 0.70, γ 0.83.
X-ray Findings: skeletal series shows no evidence of radiation osteitis. The skeleton is normal with the following exceptions: the patient has had a fusion of L4, L5, and S1 and a defect is seen in the right tibia where bone was removed for the fusion; there is deformity on the right third, fourth, and fifth ribs as a result of a thoracotomy sometime in the past; numerous droplets of radiopaque oil are seen in the subarachnoid space of the spineand in the basal cisterns of the skull as a result of a previous myelogram. Heart and lungs are normal in appearance. There is a caries of the remaining lower right molar tooth. The first upper left tooth shows a defect just below an inlay but do not know if this is due to radiation or due to caries. Similar defects are seen about the inlay of the last right upper molar.

(01-233) Born 6 April 1912. Present Health: good. Continues to have headaches as she has had for 20 years or more, at present about twice a month, up to once a week in the past. These headaches start as an occipital throbbing headache and are also felt over the malar bones. She obtains relief with hot packs; empirin tablets will also help relieve the pain.
Systems Review. HENT: patient wears glasses, had them changed a year ago, needs another change now because of difficulty with small print. Ears: negative. Nose: traumatic fracture at about age 10. About twice a year she has a pain in the bridge area, develops a postnasal drip, and then a sore throat. These tend to occur in the winter and spring. Throat: otherwise negative. No history of goiter. CV: in the past four months patient has noted that after a long day on her feet, or when she is very tired, she has an aching pain which begins in the mid-retrosternal area, radiates around under her left breast to the anterior axillary line, and then around to a position beneath her left scapula. The pain may also come on if she is very excited. It is not brought on by sudden heavy exertion. No tenderness of the area. She has also noted occasional brief palpitations

which may occur any time of day for some years. No other CV symptoms. GI: appetite good, weight steady. She has recently developed in mid-afternoon a sick feeling of the epigastrium which radiates through the upper chest; this disappears in about half an hour, is often prevented by a glass of cold water. She also has an intolerance to fried and fatty foods, cucumber, unpeeled apples, and pork. These cause nausea, epigastric distress, bloating, and belching. GU: nine years ago while in Florida, patient had urgency and frequency of urination with dysuria and hematuria. She had bladder irrigations at the time, was treated with pills, and was better in three weeks; no recurrences, no history of kidney stones. Catamenia: periods occur regularly, about every 26 days, last three to four days. Minimal menstrual symptoms. Endocrine: negative. Allergy: her headaches were said to be related to tobacco and dust allergies, noted on positive reactions with skin tests to these materials. She has also had a contact sensitivity to metals of necklaces and earrings in the past. NM: no known fractures, except for the traumatic fracture of the nose at the age of 10. Habits: she rarely smokes cigarettes. She drinks about two cocktails a day. Minimal coffee and tea consumption; milk, one quart a day. She has recently been taking geritol and "iodine ration". Past History: operations - appendectomy at the age of 12; she has had three hemorrhoidectomies, and an operation for a fistula, the most recent operation occurring in 1944. No serious injuries or illnesses. Family History: father died at age 73 with heart disease; mother died at age 27, apparently due to childbirth. One sister died at 23 with a cerebral hemorrhage; whether this was due to an aneurysm is not known. One cousin died with cancer. No family history of tuberculosis, diabetes, allergy, or epilepsy. Marital History: patient has been married 18 years. She has had no children, no pregnancies, or miscarriages. Dental History: patient has one artificial tooth. She has had about ten extractions through the years due to carious teeth. Her other teeth are in fairly good condition, needs some filling of cavities at present. Radiation Exposure: patient worked from 25 October 1927 to 8 August 1930. Her work consisted of opening radium vials, mixing a radium solution, and then either stamping or painting the radium onto the clock dials. When opening the radium she would breath the bitter fumes. She would point the paint brush when she used it with her fingers. Glowing of her clothes, skin, and hair from the waist up was noticed at night by the patient and her sister.

Physical Examination: a well-developed, well-nourished white woman, BP

116/82, pulse 84 per minute. Skin and hair were normal. HENT: eyes and ears - negative, retinal exam unremarkable. Throat: negative. Mouth: one artificial upper tooth; the lateral teeth, uppers and lowers, have been extracted. There are about 21 remaining teeth in fairly good condition. No significant lymphadenopathy. Chest: negative. Heart: no enlargement clinically, regular sinus rhythm 84 per minute, A2 greater than P2, M2 greater than M1, split first sound at the apex in the supine position. Abdomen: RLQ appendectomy scar, well-healed. Liver and spleen not felt. Pelvic and Rectal: not done. Extremities: spade-shape distal phalanx of thumb on the right; otherwise unremarkable. No ankle edema, good dorsalis pedis pulses. NM: unremarkable. CNS: unremarkable.
Lab. Findings: Urinalysis: sp. gr. 1.010, albumin neg., sugar neg., occ wbc/HPF. Hematology: wbc 7800, differential P60, L39, E1, rbc normocytic, hematocrit 39 percent. Blood chemistries: alk. phos. 3.6 units, BUN 13.9 mg percent, sugar 106 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.2, alb 4.80, TG 2.40, $\alpha 1$ 0.31, $\alpha 2$ 0.40, β 0.65, γ 1.04.
X-ray Findings: skeletal series shows no evidence of radiation osteitis. The following abnormalities are seen: the vascular markings in the skull are large but these are bilateral and symmetrical, therefore they are of no significance. The sella is poorly seen on the skull films . The heart and lungs are normal except for a small scar in the left first interspace. There is irregularity of the periarticular surface of the left astragalus, probably osteochrondritis dissecans. The liver appears large and the right kidney shadow is not seen. There is a cyst-like rarefaction in the left femoral neck. This is a little less than 2 cm in diameter and it most likely represents a cyst or enchondroma, believe it is of no clinical significance. Dental films fail to show any evidence of radiation damage.

(01-234) Born 4 June 1913. Present Health: good.
Systems Review: HENT: she wears glasses for reading. Ears, Nose and Throat: negative. No history of goiter. CV: negative. GI: good appetite. Average weight in past 10 years about 130 lbs., recent increase to 142 lbs. No food intolerances or other g.i. symptoms. GU: negative. Catamenia: patient has had regular periods up to 1954 when she began to have a year of bleeding every 3 and then 2 weeks. In 1955 she had a hysterectomy. Fibroid tumors were removed and an appendectomy was also done. Since that time she has had no bleeding or discharge. Allergy: negative. Endocrine: negative. NM: no fractures, no myalgias. Psych: frequent

sighing respirations when nervous, claustrophobia in the past year. She fainted one time at church. Habits: she does not smoke or drink. She drinks 8 to 10 cups of coffee per day. Diet is well balanced. She takes no medicines regularly except for hormone injections once a week in the past six months. Past History: operations - hysterectomy as above, T and A as a child. No serious injuries, no serious illnesses. Family History: mother died at age 36 due to childbirth; father is living at 71, has a chronic lung condition. Patient is oldest of 5 children, the other four siblings are living and well; five siblings died during infancy. No history of familial tendencies to heart disease, kidney disease, cancer, tuberculosis, diabetes, or allergy. One nephew has epilepsy. Marital History: patient has been married for 28 years. She has two children, age 27 and 11 years. She had one miscarriage between the children. Dental History: patient had 3 molar teeth extracted about the age of 13 or 14. Three upper teeth were extracted in 1932 and another tooth was removed about 2 years ago. Her remaining teeth are in fairly good condition. Radiation Exposure: patient worked with radium from 23 August 1927 to 25 August 1927 at the age of 14. She painted the radium on watch dials; the brush was pointed with the fingers. She remembers being warned not to put the brush in her mouth. She does not remember any glowing of her skin, hair, or clothes in the dark. No exposure since that time.

Physical Examination: a well-developed, well-nourished, white lady, weight 146 lbs., height 61", BP 112/74, pulse 80 per minute and regular. Skin was normal in texture, hair was coarse in texture, body hair was normal. HENT: retinal exam unremarkable. Two small white scars on the right ear drum. Nose and Throat: negative. She wears an upper bridge with four teeth. Her other teeth are in fairly good repair. Thyroid gland was not palpable. Chest: negative. Heart: no enlargements clinically, regular sinus rhythm 80 per minute, A2 greater than P2, M1 equals M2. Abdomen: liver and spleen were not felt. There was a well-healed, linear, supra-pubic scar. Pelvic and Rectal: not done. Extremities: good dorsalis pedis pulses; no edema, pallor, or tenderness. CNS: unremarkable. NM: unremarkable.

Lab. Findings: Urinalysis: sp. gr. 1.015, albumin neg., sugar neg., occ wbc/HPF. Hematology: wbc 6900, differential P60, L37, E2, B1, rbc normocytic, hematocrit 41 percent. Blood chemistries: alk. phos. 3.4 units, BUN 13.6 mg percent, sugar 143 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.2, alb 4.72, TG 2.48, $\alpha 1$ 0.32, $\alpha 2$ 0.45, β 0.61, γ 1.10.

X-ray Findings: skeletal series shows there is no evidence of radiation osteitis. An incidental finding is the presence of a right cervical rib. Dental films show there is some periapical absorption about several of the teeth. The bone as far as it is seen shows no definite evidence of radiation osteitis, neither do the teeth.

(01-235) Born 26 September 1908. Present Health: good at present. She feels that she needs a good deal of rest and feels tired all the time; this has been a chronic condition.
Systems Review: HENT: eyes - negative. Ears: decrease of hearing ability in past 5 years. Throat: patient has frequent sore throats, tend to be scratchy, maybe absent from work one to two weeks a year because of them. Nose: formerly treated frequently for sinus condition, feels better now. She denies goiter or thyroid trouble. Chest: when younger, patient was told that she had a nervous heart, goes fast, apparently because of occasional tachycardia. GI: patient has chronic constipation, uses no laxatives at the present. Fatty foods may cause nausea and vomiting. GU: no symptoms at present. She states that she had gravel in her urine 10 to 15 years ago and that a small stone was crushed in the bladder. She followed a low calcium diet for some years. Catamenia: menopause apparently ended about 3 months ago. During her life periods have been regular, although scant. Allergies: when younger she had hives at different times, none recently. No definite allergies known. Endocrine: she was told she had too much calcium after her kidney gravel attack. NM: no known fractures, occasional aches in the thighs. Habits: she does not smoke. She occasionally drinks cocktails. Coffee intake about 4 to 5 cups a day. Medicines - she takes vitamins and some pills for her fatigue regularly. Also takes iodine ration pills occasionally. Past History: operations - patient has had two tonsillectomies, she had an appendectomy about 1935. In the 1930's she sustained several superficial wounds of the left upper arm from a charge of buckshot that was accidentally set off. She denies any serious injuries. Illnesses - she had a nervous breakdown 5 years ago at which time she spent three months in a state hospital. No history of rheumatic fever, tuberculosis, diabetes; she has had pneumonia and flu. Family History: father died at age 41 of pneumonia, mother died at 55 with cancer, type unknown. She has one sister and one brother who are living and well, and one well step-sister. Two brothers died in infancy. No familial history of heart or kidney disease, of allergy, or epilepsy. Marital History: patient has

never married, no pregnancies. Dental History: patient states that she began in her teens to have cavities and soft teeth. She believes that she has had about twelve teeth extracted at various times; the last ones were removed about 7 to 10 years ago; the remaining teeth have been in fair condition but tend to chip easily. She wears an upper bridge. Radiation Exposure: patient worked from 22 September 1925 to 8 November 1925 at the age of 18. At that time she worked with radium painting the watch dials and remembers pointing the brush with her mouth. She also remembers frequent glowing of her clothes at night. She has had no other known radiation exposure.

Physical Examination: a well-developed, well-nourished, hyperkinetic white lady who appeared in good health, weight 139 lbs., height 62-1/4", BP 140/80 (right arm, supine), pulse 80 per minute. The skin was smooth, warm, and dry. The hair of the scalp was fine in texture, body hair appeared normal. No significant lymphadenopathy. HENT: extraocular movements normal, fundi appeared normal. Nose: negative. There was some lymphoid hyperplasia of the oral pharynx. She had seven of her own upper teeth and thirteen lower teeth in fair condition. There was an upper bridge. Neck: there was a 1 cm nontender, movable nodule located in the midline of the anterior neck above the thyroid isthmus. This nodule moved with swallowing. It did not appear to transilluminate. No stalk could be felt. Chest: negative. Heart: regular sinus rhythm 80 per minute, grade 1 soft systolic murmur at the base, A2 greater than P2, M2 greater than M1. Abdomen: the liver and spleen were not felt. There was a well-healed linear transverse RLQ appendectomy scar. Pelvic and Rectal: not done. Extremities: no deformities, hands were slightly moist. CNS: negative. NM: negative. Lab. Findings: Urinalysis: sp. gr. 1.015, alb neg., sugar neg., occ wbc/HPF. Hematology: wbc 4900, differential P49, L47, E1,M3, rbc normocytic, hematocrit 38 percent. Blood chemistries: alk. phos. 6.6 units, BUN 16.8 mg percent, sugar 95 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.8, alb 5.35, TG 2.43, $\alpha 1$ 0.31, $\alpha 2$ 0.47, β 0.64, γ 1.01. X-ray Findings: skeletal series fails to show any evidence of radiation osteitis. There is some soft tissue calcification present close to the anterior iliac spine on the left side. The underlying bone shows no evidence of destruction. Most likely, this calcification is a tendon insertion. Dental films show no evidence of radium osteitis. No peridental disease is seen.

(01-237) Born 21 September 1907. Present Health: good, strength is good; she works regularly.
Systems Review: HENT: she had occasional temporal, throbbing headaches in the past two years associated with the menopause. These headaches cause occasional nausea and vomiting. She wears glasses for reading. Ears: negative. Nose: negative. Throat: frequent sore throats before a tonsillectomy in 1944, few symptoms since. CV: negative. Occasional dry cough in the morning. GI: appetite good. Average weight 144 lbs., weight is steady. She has had an occasional feeling of a lump in the midretrosternal area after eating a large meal fast. The sensation is usually relieved by belching. It may occur about once a month. She has had no fried or fatty food intolerances in the past. GU: negative. Catamenia: periods were regular until about two years ago when she began the menopause. She has had headaches and occasional hot flashes. She has had no periods for the past five months. Allergy: negative. No known reactions to medicines. Endocrine: she was told her thyroid was enlarged during one pregnancy, has not noticed a goiter since. NM: no fractures. She has occasional right elbow pain in the past year. No swelling or severe pains. Habits: she smokes about one pack of cigarettes every two days. Alcoholic intake is very moderate. She tends to drink five to six cups of coffee per day. She takes vitamins regularly, has also had pills for the menopause. Past History: operations - tonsillectomy in 1944. Illnesses - typhoid fever at age 10 years. No history of rheumatic fever, nephritis, tuberculosis, or diabetes. Serious injuries none. Family History: father died at age 72 in an accident; mother died at age 68, cuases not known. No known family history of heart or kidney disease or of cancer, tuberculosis, diabetes, allergy, or epilepsy. She has five brothers and five sisters all of whom are living and well. Marital History: patient was married in 1927, separated around 1947, and has been a widow for four years. She had five children, the last two of whom were twins. The pregnancies and deliveries were normal. She had no miscarriages. Four of these children are married; each one of them have had children so that she has eleven grandchildren. Dental History: she feels her teeth were good until time of her pregnancies when she was in her third decade. At that time she had many cavities and had about seven teeth extracted at different times then. Two to three other teeth were also extracted, the last two in 1946. Her other teeth have given her little trouble since that time. She has a lower plate containing five teeth. Radiation Exposure: she worked from 23 February 1927 to 14 April 1927

at the age of 19. She painted watch dials with a brush but does not remember pointing the brushes with her lips; she thinks she may have done it with her fingers. She does not remember glowing of her skin, hair, or clothes at night. No further exposure with radium.
Physical Examination: a well-developed, well-nourished, white lady who appears to be in good health, weight 115 lbs., height 62", BP 112/70, pulse 76 per minute and regular. HENT: retinal exam unremarkable, extra-ocular movements normal. Nose, Ears, and Throat: negative. Thyroid gland is enlarged, both lobes are palpable, soft, no bruit. Estimated glandular weight 35 to 40 grams. Chest: no increase in P. A. diameter, resonant, no pulmonary rales. Breasts: negative. Heart: regular sinus rhythm 76 per minute, A2 greater than P2, M2 greater than M1. Abdomen: liver and spleen were not felt. Pelvic and Rectal: not done. Extremities: no deformities, no ankle edema, good dorsalis pedis pulses. CNS: sensation normal, deep tendon reflexes are equal and symmetrical, flexor plantar responses. Skin: normal texture. Scalp and body hair normal in texture and amount. No significant lymphadenopathy.
Lab. Findings: Urinalysis: sp. gr. 1.010, albumin neg., sugar neg., occ wbc, few epith/HPF. Hematology: wbc 3300, differential P59, L41, rbc normocytic, corr. sed. rate 0.1 mm/hr., hematocrit 43 percent. Blood chemistries: alk. phos. 3.5 units, BUN 15.9 mg percent, sugar 100 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.2 , alb 4.75, TG 2.43, $\alpha 1$ 0.27, $\alpha 2$ 0.50, β 0.68, γ 0.98.
X-ray Findings: skeletal series shows there is no evidence of radiation osteitis. The skull is normal in appearance. The heart and lungs show no abnormality. The only abnormality seen in the skeletal survey consists of calcification in the region of the right greater tuberosity of the humerus as seen in bursitis. Dental films show the remaining teeth and adjacent alveolar processes negative for radiation osteitis.

(01-238) Born 18 November 1896. Present Health: patient states that she was in good health until about a year ago when she began to notice first a weakness of the legs and then extreme difficulty of balance so that she was unable to walk, turn around, or go upstairs without either the support of a wall, furniture, or another person. There has apparently been no progress of these signs and symptoms in recent months. She feels well otherwise and states that her strength is good and is able to do all of her housework including the cooking and making of beds. She does not go out. She

has gained 25 lbs. in the past year. She denies vertigo or lightheadedness, diplopia, and tinnitus. Her illness was investigated 4 months ago. Physical examination at that time revealed some cerebellar signs. An EGG was abnormal with nonspecific changes. Some changes suggested a seizure potentiality. The diagnosis was cerebellar degenerative disease. Habits: she does not smoke, she tends to drink 1 or 2 glasses of beer per day. She likes ice cream and cheese and drinks about 2 glasses of milk a day. She takes no medicines regularly at present. Past History: operations - patient had a tonsillectomy about age 51, apparently for a prophylactic measure. Illnesses: see above. Injuries: negative. Family History: father died at age 71, question liver disease; mother died at age 61, with heart disease. One sister is allergic to penicillin. No known tendency to cancer familially. No known familial tendency to tuberculosis, diabetes, kidney disease, or epilepsy. She has 4 brothers and 3 sisters, all living and well. Marital History: patient has been married 34 years and has one son,age 18, who was born when she was 45 years old. She has had no miscarriages or other pregnancies. Dental History: she cannot remember the state of her teeth when she was young. She states that she had all of her teeth up to about 5 years ago. She has had cavities filled in the past. Over the course of a year she then had all of her teeth out because of more extensive cavity formation. She has worn an upper and lower plate for 3 or 4 years. Radiation Exposure: she is unable to remember the details of her exposure but according to company records she worked from 11 October 1920 to 20 October 1920 when she was 23 years old. She believes she painted watch dials for a very short time and does not think that she pointed the brushes with her lips. She denies any glowing of skin, hair, or clothes at night. She has had no other known radium exposure.

Physical Examination: a well-developed and very well-nourished white female who is ataxic, walks with a broad base, and is unable to turn without help; weight 144 lbs., height 62", BP 170/100, right arm, pulse 80 per minute. The skin is normal texture; body and scalp hair were normal in texture. No significant lymphadenopathy. HENT: there was a left lateral nystagmus. Retinal examination revealed some narrowing of the arterioles. Poor light reflex of the left eardrum. Nose and Throat: negative. Patient was completely edentulous and wore upper and lower plates. The thyroid gland was just palpable. Chest: negative. Heart: regular sinus rhythm, 80 per minute. A2 greater than P2, M2 greater than M1. Breasts: negative. Abdomen: liver and spleen not felt. Pelvic and Rectal: not done.

Extremities: no ankle edema. Good dorsalis pedis pulses, no calf tenderness. CNS: patient has slightly slurred speech. She showed some perseveration in commands. Finger-nose test: showed only fair performance. There was a dysdiadochokinesia. Stereognosis was good. Toe-heel test: somewhat better on the right than on the left. Romberg: positive. Deep tendon reflexes were hyperactive, equal, and symmetrical. The plantar responses were flexor. Sensation appeared intact to touch, pin prick, and vibration. In short, these findings were similar, and perhaps somewhat improved, to the investigation in June 1959.
Lab. Findings: Urinalysis: sp. gr. 1.015, albumin neg., sugar neg., 0-2 wbc/HPF, 0-4 Ca oxalate crystals/HPF. Hematology: differential P72, L27, E1, rbc normocytic, corr. sed. rate 1 mm/hr., hematocrit 38 percent. Blood chemistries: alk. phos. 6.2 units, BUN 15.5 mg percent, sugar 155 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.4, alb 3.96, TG 2.43, $\alpha 1$ 0.38, $\alpha 2$ 0.49, β 0.64, γ 0.92.
X-ray Findings: skeletal series shows no evidence of radiation osteitis. Both feet, knees, and both hands show osteoporosis.

(01-244) Born 1 January 1901. Present Health: patient has been in a mental hospital since March 1939, dementia praecox, catatonic. Had lobotomy at some time in the past. Marital History: married in 1927 to present, husband living and well, has five children. Occupational History: luminous watch dial painter 20 May 1927 to 24 September 1927. No physical exam, x-ray, or laboratory work done.

(01-245) Born in 1920. Luminous dial painter for 7 months in 1957. No physical exam, x-ray, or laboratory work done.

(01-246) Born in 1885. Worked in radium clinic for 8-9 months between 1915 and 1916. No physical exam, x-ray, or laboratory work done.

(01-247) Born 9 November 1901. Present Health: patient feels that he is in good health at present. He has chronic signs of radiation disease described below under Radiation History.
Systems Review. HENT - Eyes: negative. Ears: negative. Nose and Throat: negative, no headaches. CV: negative, except that he was told on a very brief examination that he had a palpitation of his heart a few months ago. He has not noticed any irregularities himself or had any symptoms. GI:

appetite good, no food intolerances. He had hemorrhoids in the past, no symptoms for 15 to 20 years. No other symptoms. GU: about 1924 he had a right perinephric abscess and was operated upon at a private hospital. He had no preceeding g.u. symptoms and has had no symptoms since. Patient had fertility studies some 20 to 22 years ago and states that on some examinations nonmotile sperm were seen. After a period of treatment (type?) some motile sperm were seen. He has never had any children, however. Allergy: no hives, hay fever, or asthma; no known reactions to medicines. NMS: no fractures, no bony pains. Endocrine: no goiter, no symptoms of thyroid disease. Habits: use of tobacco (pipe) is moderate. Alcohol intake is low. He takes no medicines regularly. Intake of milk and coffee is relatively low. Average weight was 195 to 200 lbs. Although he is not aware of it weight at present seems to have decreased to 180 lbs. Past History: operations - perinephric abcess as above. He had two tonsillectomies, one as a child, the other at age 25. Serious illnesses: see under Radiation History. Serious injuries: none. Family History: mother died at age 72 of pneumonia. She had Parkinson's disease. Father died at age 83, apparently of Bright's disease. No history of heart disease, cancer, tuberculosis, diabetes, allergy, or epilepsy in the family. He has one sister, age 66, who is living and well. She apparently had hyperthyroidism and a partial thyroidectomy. Marital History: patient has been married 26 years. He has two adopted children. See G.U. above. Dental History: patient has had about 10 extractions within the past 10 years and has had various cavities. He feels that his remaining teeth are in fairly good condition. He has had no dental attention for 4 years. Radiation History: from December 1923 to June 1926, age 22 to 25, he worked for a radium company. His work concerned the refining of the ore to the finished material. He worked with the chloride and bromide crystallization procedures. No precautions were observed. Glowing fumes could be observed in the laboratories at night. As an example of the magnitude of the materials, he states that about six hundred tons of ore were necessary to produce one gram of radium. For three months in 1926 he learned how to run a radon plant. He then worked for four years from July 1926 to February 1930 with x-ray diffraction apparatus. The equipment was made by the people concerned in its use, probably no more than 65 kv machines. From March 1930 to the end of 1937 he worked with a radon plant containing 2 grams of radium in solution. When he first started working two men only ran the plant. At the end of 1937 he began to have some skin breakdown on the fifth finger

of the right hand. There was some healing, then recurrence of the breakdown. He was seen by two doctors and the diagnosis was Bowen's disease. A Thiersch graft was performed on the finger with good results. Since that time he has had several tan keratotic areas on the thenar and hypothenar eminences, the volar surfaces of the wrists, and on the top of his head. These radiokeratotic areas were treated by electrodessication and more recently by liquid nitrogen with good results. He stopped all radium work in 1938. Since that time he has worked in x-ray calibration and protection work.

Physical Examination: height 6', weight 181 lbs., BP 128/78, pulse 76 per minute. A well-developed, well-nourished, healthy appearing white man. Skin: he has several epilidies over his skin. There are pigmented scars of shin scrapes on his legs. On his anterior scalp, his wrists, and palms are punctate scars of treated keratotic areas. On the ulnar surface of the fifth digit of the right hand are the scars of the Thiersch graft. Hair: balding. Scalp and body hair normal in texture. HENT - EOM: normal, retinal exam negative. Nose: negative. On the right buccal mucosa just inside the oral commissure is a 2 to 3 millimeter bluish area suggestive of hemangioma. On the right buccal mucosa far back is a similar lesion. There are several absent teeth in upper bridge. The remaining teeth contain cavities. They appear carious. Thyroid not palpable. Chest: resonant, no pulmonary rales. Heart: regular sinus rhythm 76 per minute, A2 greater than P2, M2 greater than M1. Abdomen: liver just palpable under the right costal margin, spleen not felt. Genitalia: testes are small, firm. Rectal: prostate normal in size, no tenderness, no masses felt. Extremities: no deformities except of the skin as noted above, no ankle edema, good dorsalis pedis pulses. CNS: deep tendon reflexes, 1 to 2 plus in the upper extremities, 2 to 3 plus in the lower extremities, flexor plantar responses.

Lab. Findings: Urinalysis: not done. Hematology: wbc 4700, differential P56, L44, rbc normocytic, corr. sed. rate 10 mm/hr. hematocrit 47 percent. Blood chemistries: alk. phos. 5.8 units, BUN 22 mg percent, sugar 104 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.7, alb 5.11, TG 2.59, $\alpha 1$ 0.33, $\alpha 2$ 0.64, β 0.69, γ 0.93.

X-ray Findings: skeletal series shows no evidence of radiation osteitis. Incidental findings are: numerous calcified bodies in the right knee joint in an otherwise normal-appearing joint, most likely due to osteochondromatosis. There are moderate degenerative changes in the dorsal and lumbar

spine. There is some calcific tendinitis in both shoulders. There is calcification of arteries considerably more marked than is seen in the average patient of this age. Dental films show no evidence of radiation necrosis. There are some repaired caries and some that are not repaired. There is resorption of the bone about two of the upper left teeth as seen with granuloma.

(01-248) Born 11 May 1903. Present Health: good and has been in recent years except for a tendency to be nervous.
Systems Review. Eyes: wears glasses now and has for several years. Thinks she may need new ones soon. No other difficulties. Ears: negative. Nose and Throat: normal. No history of any swollen glands in the neck or elsewhere. CR: negative. GI: subject to attacks of indigestion; the last severe one was approximately two years ago. Had a GI series which was reported as negative. Diagnosis at that time, nervous indigestion. Bowels usually regular. No history of any blood in the stools. GU: normal. Catamenia: menarche at age 13; periods regular until hysterectomy at age 35. This was followed by severe hot flashes for several years. None at the present time. NM: has been subject to low back pains off and on for the last 20 years. She is also subject to quite severe headaches at frequent intervals which she attributes to nervous tension. No skin abnormalities. Habits: appetite good. No weight change in recent years. Sleeps soundly, does not smoke, no alcohol consumed. Past History: had the usual childhood diseases, and also had diphtheria. No specific history of scarlet fever, rheumatic fever, allergy, epilepsy, or mental illness. Operations consist of tonsillectomy, appendectomy in youth, and hysterectomy as noted above. No other hospitalizations, accidents, injuries, or fractures. No other confining illnesses. Family History: father died at age 80 of a stroke; mother, 84, living and well. Six siblings living and well. One sibling killed in an accident. Mother had a small cancer of the breast removed a few years ago; otherwise no family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental illness. Marital History: patient is single and has never been married. Dental History: has had many fillings in the course of her life, but has actually lost only five or six teeth altogether. No difficulty with healing of teeth after extraction. Radiation Exposure: patient states that she painted watch dials starting at the age of 14 in 1917 until she was 18 years old. This work was done

mostly after school and during vacations both in the winter and summer. She and others working with her regularly pointed the brush in the mouth. She does not remember any glowing of the hair or clothing at night.
Physical Examination: an alert, healthy appearing woman of 56, height 63.5", weight 115 lbs., BP 100/70, pulse 74 and regular. Eyes: pupils and extra-ocular movements normal, although there is some suggestion of exophthalmos. There is, however, no sign of any other stigmatism suggesting hyperthyroidism. Ears: normal. Nose and Throat: negative. Remaining teeth in good state of repair. Neck shows no evidence of cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: soft and relaxed. Liver and spleen not made out. Well-healed low midline scar. Pelvic and Rectal: not done. Extremities: normal. Reflexes: equal and active.
Lab. Findings: Urinalysis: sp. gr. 1.014, albumin neg., sugar neg., occ epith/HPF. Hematology: wbc 4700, differential P51, L40, E2, M7, rbc normocytic, corr. sed. rate 6 mm/hr., hematocrit 38 percent. Blood chemistries: alk. phos. 4.2 units, BUN 16.2 mg percent, sugar 84 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.1, alb 4.4, TG 1.7, $\alpha 1$ 0.26, $\alpha 2$ 0.42, β 0.63, γ 0.43.
X-ray Findings: skeletal series shows no evidence of radium poisoning. The bones of the extremities show a mild osteoporosis and some minimal degenerative changes about the knee joints and about the first metatarsal phalangeal joints where there is a bilateral splayfoot deformity. The heart and lungs are normal in appearance. Dental films of the remaining teeth show no evidence of radiation osteitis in the adjacent maxilla or mandible.

(01-249) Born in 1928. Son of case 01-049. Married, one child living and well. No physical exam, x-ray, or laboratory work done.

(01-250) Born 16 July 1894. Present Health: good and has been for many years. He remembers no time lost from work because of illness for a long time.
Systems Review: no abnormalities of the eyes, ears, nose, or throat, except for one episode of rather severe epistaxis in 1956 when he was hospitalized. This epistaxis required a postnasal pack. He has had no difficulty along this line since that time. No history of any swollen

glands in the neck or elsewhere. CR: negative. GI: normal. Bowels regular without laxatives, no history of any blood in the stools. GU: negative except for occasional episodes of nocturia. NM: he was troubled with intermittent attacks of bursitis in the right shoulder many years ago, none in recent years. Skin: has had acne rosacea for many years. This he is able to keep under fair control with local applications and attention to diet. Habits: appetite good, weight has remained the same in recent years, sleeps soundly at night. He has never smoked, never taken any alcohol, exercise is rather variable. Past History: he had the usual childhood diseases but no specific history of scarlet fever, diphtheria, rheumatic fever, epilepsy, allergies, or mental disorder. Only hospitalization he can remember was that for epistaxis as noted above. No operations, accidents, injuries, no history of any fractures. He was subject to low back pain in the distant past but none in recent years. Family History: father died at 68 with diabetes; mother died at 73. She was also diabetic although she died of pneumonia. One brother, age 63, living and well, no other siblings. No family history of cancer, tuberculosis, any other diabetes, no allergies, epilepsy, or mental disorder. Marital History: married 33 years at present time, wife, 67, living and well. One daughter,age 30, living and well with three children. No other children, this by choice. Dental History: has lost only six to eight teeth over the years, no difficulty with healing after extractions of these teeth. Radiation Exposure: as an engineer for a watch company, he had occasion to handle the luminous paint for an extended period of time beginning in 1916 to 1938. It was part of his job to test luminosity of the luminous paints, occasionally he did some weighing of the materials. The exposure was much more intimate for the first ten years than the last ten years.

Physical Examination: a well-developed and nourished, healthy-appearing man of 65, weight 152 lbs., height 67-1/2", BP 150/80, pulse 82 at rest and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Remaining teeth in good repair. Neck shows no cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Abdomen: soft and relaxed, liver and spleen not felt, inguinal rings normal. Genitalia: normal. Reflexes: somewhat hyperactive but equal.

Lab. Findings: Urinalysis: sp. gr. 1.020, albumin neg., sugar neg., occ wbc/HPF. Hematology: wbc 4100, differential P64, L36, rbc normocytic,

corr. sed. rate 6 mm/hr., hematocrit 44 percent. Blood chemistries: alk. phos. 5.9 units, BUN 17.6 mg percent, sugar 162 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.2, alb 4.05, TG 2.14, $\alpha 1$ 0.23, $\alpha 2$ 0.29, β 0.54, γ 1.08.
X-ray Findings: skeletal series fails to show any evidence of radiation osteitis. No abnormalities are seen. The aorta is slightly elongated but not necessarily abnormal for a patient of this age. Dental films show no evidence of peridental disease and no evidence of radiation osteitis.

(01-251) Born about 1889. Living and in fairly good health. Chemist in radium refinery from 1912 to 1915 starting about age 22. Past medical history shows some evidence of heart disease. No apparent effects from radiation 47 years after exposure. No physical exam, x-ray, or lab. work done.

(01-252) Born about 1899. Living and in fair health. Luminous dial painter for approximately 3 years, 1917-1919, starting at about age 18. Teeth removed in 1954 because of restorative procedures elsewhere in mouth. Past medical history shows headaches, loss of weight, insomnia since 1957 probably due to chronic invalidism of husband. No physical exam or laboratory work done. X-rays negative. No apparent effects from radiation 42 years after exposure.

(01-253) Born in 1898. Living and in good health. Luminous dial painter for 1-5 years starting in 1916 or 1917 at about age 18. Hysterectomy in 1929, allergic to house dust. No physical exam, x-ray, or laboratory work done.

(01-255) Born 15 September 1920. Present Health: good and has been in recent years. She has lost no time from work because of any illness. Systems Review. Eyes, ears, nose and throat: normal. A few upper-respiratory infections. No history of any swollen glands in the neck or elsewhere. CR: some morning cough, otherwise no symptoms. GI: normal. Bowels regular without laxatives. No history of any blood in the stools. GU: negative. Catamenia: menarche at age 13. Periods always regular. No intermenstrual bleeding or discharge. NM: normal. No skin abnormalities. Habits: appetite good. Slight weight gain in recent years. Sleeps soundly at night. Does not smoke. No alcohol consumed. Exercise consists mostly of housework and running a Brownie troop. Past History: usual childhood

diseases. No specific history of scarlet fever, diphtheria, or rheumatic fever. No history of any allergy, epilepsy, or mental illness. No operations, accidents, injuries, or fractures. No confining illnesses. Family History: father died at age 57 of an accident; mother, age 65, living and well. Five siblings living and well. Father had a cancer at the time of his death. Also, maternal grandmother had a cancer. Otherwise no other familial history of cancer, diabetes, or tuberculosis. No history of any allergy, epilepsy, or mental illness in the family. Marital History: married 16 years to the present time. Husband, age 38, living and well. Three children ages 14, 12, and 10 living and well. No other pregnancies. Dental History: has lost three teeth only up to the present time. Radiation Exposure: did dial painting from September 1942, when the patient was 22 years old, to September 1943. Work was all done under very carefully controlled conditions, most of it under hood. Breath radons were done from time to time. There was no putting the brush in the mouth at any time.

Physical Examination: a well-developed,nourished, healthy-appearing person of 39, weighing 133 lbs., height 66.5", BP 128/70, pulse 84 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Teeth in good repair. Neck shows no cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Abdomen: soft and relaxed, no masses felt. Breasts: normal female, no masses noted. Pelvic: done at patient's request showed no abnormalities. Extremities:normal. Reflexes: equal and active.

Lab. Findings: Urinalysis: sp. gr. 1.010, albumin neg., sugar neg., 6-8 epith/HPF. Hematology: wbc 8100, differential P70, L28, E2, rbc normocytic, corr. sed. rate 21 mm/hr., hematocrit 38 percent. Blood chemistries: alk. phos. 2.9 units, BUN 16.6 mg percent, sugar 94 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.7, alb 4.3, TG 2.4, $\alpha 1$ 0.26, $\alpha 2$ 0.44, β 0.67, γ 1.08.

X-ray Findings: skeletal series including the skull, actual skeleton, pelvis, long bones, and chest shows no evidence of radium poisoning. There are some radiolucent shadows seen near the midline in the PA film of the skull. They are probably in the frontal bone. No very good explanation for them although they certainly are not due to radium. Except for this radiation which is of no significance, the skeletal survey is normal. Dental films show a retained root fragment in the left upper central incisor area. There is some general absorption about the right lower first molar.

Otherwise, no evidence of peridental disease is seen.

(01-256) Born in 1920. Chemist working on radium standardization and certification for 4 years from 1949 to 1952. No physical exam, x-ray, or laboratory work was done.

(01-257) Born about 1885. Chemist at a radium company for 12 years from 1941 to 1953. In 1959 had severe heart attack followed by complications which resulted in the amputation of his left leg. No physical exam, x-ray, or laboratory work done.

(01-258) Born about 1900. Chemist in a radium laboratory intermittently between 1923 and 1944, total exposure time about 16 years. Health considered to be excellent. No physical exam, x-ray, or laboratory work done.

(01-259) Born in 1910. Laboratory worker in a radium clinic for 10 years from 1927 to 1937. Married, has 2 children living and well. No physical exam, x-ray, or laboratory work done.

(01-260) Born in 1891. Drank "Ra water" for 2-3 years between 1918 and 1923 at age 27. No physical exam, x-ray, or laboratory work done.

(01-261) Born 23 July 1909. Present Health: there are only two things that have bothered her, one of which started with a terrible epigastric pain early in January of 1959 which followed eating fried bread dough. This lasted 24 hours. She was x-rayed and found to have a normal gallbladder, but a GI series showed apparently a duodenal ulcer. She was placed on Malox, a green tablet, and an ulcer diet. At present she follows the diet only, has gained 20 lbs., but has no more distress. The second complaint is that about ten years ago she began to have left hip pain which radiated down the leg. This has continued through until the present time. She had an examination in 1951 and was told that she had an extruded disc with calcification. She uses a bed board, takes aspirin, and has good and bad days, says she walks without limp. There is some question as to whether or not she has bursitis of her hip.
Systems Review: a many-year history of migraineheadaches which did not respond to Ergotrate and do respond to codeine and aspirin. She says these are preceded by flashes of light in the left field of vision, but these

headaches are frontal in nature and are frequently confused with a sinus headache. No fits or epilepsy. Eyes: wears glasses for reading. Ears: good hearing. In 1949 has an abscess of her right ear with a short period of tinnitus. Nose: no epistaxis, uses nose drops for sinus trouble. Throat: has had several streptococcal sore throats in the past several years. Neck: no goiter or history of goiter. Breasts: no masses or infections have been noted. CR: no pneumonia, hemoptysis, or cough. No chest pains. Ankles swell only from arthritis. No history of hypertension, heart murmurs, or rheumatic fever. GI: appetite good. No food dyscrasias. Note above ulcer history. Says she will not have a bowel movement unless she takes laxatives, and this is usually milk of magnesia. Mallox constipated her, and following an episode of hard stools she had slight rectal bleeding. GU: twenty-eight years ago she was said to have had gravel in her urine but has had no trouble since that time. No nocturia, no dysuria. Catamenia: menarche at age 13; for the past three years she has had irregular periods coming every four to six months. Last menstrual period was the first week in June. She has occasional hot flashes. There is no vaginal burning, itching, or discharge. NM: her fingers and toes are stiff when she arises in the morning, but this works off by the end of the day. No known varicose veins, no leg cramps on walking. Habits: twenty cigarettes a day, alcohol none, occasional aspirin and pyribenzamine. Sleeps eight to ten hours a night. Past History: operations - at age three to four, purulent glands were drained on her neck; at age 23, appendectomy; at age 22, an operation on her paranasal sinuses of some sort. Serious illnesses: meningitis, age one year. No details known about this. Allergies: has seasonal hay fever for which she takes pyribenzamine, prn. No known asthma, but at one time when she was receiving desensitization shots for her hay fever; had some congestion of her lungs. If she takes Anacin she will get itching and burning of her throat, hands, and feet with urticaria. Quinine has caused her to faint and to develop giant urticaria. Family History: father living, 76, in fair health. Mother died at age 58, cancer of the uterus. A sister died, aged 28, of pneumonia. Sister living and well; brother living with hepatitis, who is not an alcoholic; a maternal aunt had diabetes. Marital History: is married. Has two children, a 28-year-old boy who has asthma, and a 29-year-old daughter who is in good health. Dental History: has her own teeth, many of which are missing. Sees her dentist twice a year. Radium Exposure: until it was recalled to her she had completely forgotten that she ever worked painting watch dials. She

worked from 26 April 1927 to 7 May 1927. She thinks she was told never to put the brush in her mouth. She does not recall ever glowing in the dark. Physical Examination: height 64-3/4", weight 163 lbs., BP 162/88, pulse 100. Head. Eyes: pupils equal, react to light and accommodation. Extra-ocular movements normal, fundi normal. Ears: small amount of cerumen, drums normal, hearing acute. Nose: negative. Mouth: has a number of missing teeth; otherwise within normal limits. Tongue well papillated. Neck: scars on both sides of the neck, surgery done in childhood. Palpable, slightly enlarged isthmus of the thyroid gland. Breasts: large, no masses or tenderness. Lungs: good breath sounds, no rales, good percussion. Heart not enlarged, rhythm regular, good tones, no murmurs. Abdomen: old appendectomy scar. No organs, masses, or tenderness. Good femoral pulsations. Pelvic and Rectal: not done. Extremities: good pulsations, no joint pathology, no edema. Neurological: within normal limits. Diagnoses: obesity; duodenal ulcer, by history; protruding intervertebral disc, by history.
Lab. Findings: Urinalysis: sp. gr. qns, albumin neg., sugar neg., 3-5 epith. cells, 0-1 wbc/HPF. Hematology: wbc 8000, differential P47, L49, E4, rbc normocytic, corr. sed. rate 25 mm/hr., lymphs appear to be of the small mature type. Blood chemistries: alk. phos. 4.0 units, BUN 16.5 mg percent, sugar 107 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.1, alb 5.05, TG 2.05, $\alpha 1$ 0.18, $\alpha 2$ 0.55, β 0.67, γ 0.65.
X-ray Findings: skeletal series shows no evidence of radium poisoning. No abnormality is seen. Dental films show several of the molars and premolars in the upper jaw to be missing. The remaining teeth are normal in appearance except for opaque fillings. There is a defect in the left lower first premolar which may be either a nonopaque filling or an area of cavitation; no local abscesses or bony abnormalities are seen.

(01-262) Born about 1900. Laboratory worker for a short time in 1918 or 1919. No physical exam, x-ray, or laboratory work done.

(01-263) Born in 1897. Luminous dial painter for approximately 4 months in 1917 or 1918, starting at about age 19. No physical exam, x-ray, or laboratory work done.

(01-264) Born in 1906. Repaired luminous aircraft instrument dials for over 15 years starting in 1944 at age 38. No physical exam, x-ray, or

laboratory work done.

(01-265) Born 17 December 1902. Present Health: good at the present time and has been in recent years. She has lost no time from her work. Systems Review. Eyes: changed glasses two months ago; otherwise no difficulties. Ears: negative. Nose and Throat: normal, except for occasional upper respiratory infection. No history of any swollen glands in the neck or elsewhere at the present time. Did have gland removed during childhood. CR: occasional precordial pains but these bear no relationship to any exertion. No cough or other cardiorespiratory symptoms. GI: occasional nausea but nothing persistent in the way of definite indigestion. Bowels regular without laxatives. No history of any blood in the stools. GU: nocturia once or twice per night for many years. No history of any vaginal discharge. Catamenia: menarche at age 16. Periods regular until the age of 52 or 53. Has had occasional slight staining since that time, the last time being two weeks ago. Has had no pelvic examination for ten years. NM: occasional pains in the left knee. Some paresthesias of the left leg. No history of any headaches. No skin abnormalities. Habits: appetite good. Some weight gain in recent years. Sleeps soundly at night. Tobacco comsumption minimal. Alcohol consumption four to five drinks per week. Gets moderate amount of exercise camping and taking walks. Past History: had the usual childhood diseases, but no specific history of scarlet fever, diphtheria, or rheumatic fever. No allergy, epilepsy, or mental illness. Operations consist of removal of gland left side of neck in childhood. Had a bad accident requiring much operative repair of right wrist at age 18; no residual difficulty. Broke left ankle ten years ago by tripping over a log. Had pneumonia in childhood. Family History: father died , age 62, of heart disease; mother, age 84, with some heart disease. Three siblings living and well. One sibling died of cancer of the breast at age 42. No other family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental illness. Marital History: married 33 years to the present time. Husband, age 53, living and well. No pregnancies at any time, whether by design or accident not elicited. Dental History: has lost 12 teeth during the years. No trouble with healing of gums after extraction. Radiation Exposure: painted watch dials from 24 November 1919 to 1 December 1919 at the age of 16. Denied ever putting the brush in her mouth as she thought it a dirty thing to do. Does not remember any glowing of the hair or clothing at night. States that it was because she was unable to get the

work done quickly enough, presumably because of not pointing the brush in the mouth, that she left this type of employment.
Physical Examination: a well-developed and nourished woman of 56 in no apparent distress, weight 147 lbs., height 60", BP 120/70, pulse 86 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Remaining teeth in good repair. Neck: no cervical adenopathy, but there is some slight fullness in the region of the thyroid gland. No evidence of hyperthyroidism except for a slight tremor of the extremities. Heart and Lungs: normal to auscultation and percussion. Breasts: right, normal female, no masses felt;left, nipple inverted and a feeling of greater density in this left breast in region of 12 o'clock. This probably represents no real pathology but would bear watching. Abdomen: soft and relaxed. Liver and spleen not felt. Pelvic: done at patient's request shows a small atrophic uterus, ovaries not made out. Cervix small and scarred, presumably from a previous cauterization done many years ago. Rectal: negative except for question of a small anal fissure. Extremities: normal except for extensive scarring in region of right wrist from accident noted above. Reflexes: somewhat hyperactive.
Lab. Findings: Urinalysis: sp. gr. 1.027, albumin neg., sugar neg., 2-4 epith/HPF, 6-8 wbc/HPF. Hematology: wbc 6300, differential P53, L47, rbc normocytic, corr. sed. rate 27 percent, hematocrit 40 percent. Blood chemistries: alk. phos. 4.3 units, BUN 16.8 mg percent, sugar 80 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.3, alb 4.7, TG 2.6, $\alpha 1$ 0.23, $\alpha 2$ 0.52, β 0.70, γ 1.14.
X-ray Findings: skeletal series shows the right frontal sinus as opaque and its margins appear escalloped. This could be just a fluid-filled sinus but the appearance suggests more that the patient has mucocele or serous-filled cyst in the right frontal sinus. The right antrum shows marked thickening of the mucoperiosteum and probably polypoid degeneration. The other sinuses are normal. Except for these changes in the sinuses which are not believed to be related to radium poisoning, the skeletal survey shows no abnormalities aside from degenerative changes consistent with the patient's age. Some small calcifications are present in the spleen most likely due to tuberculosis some time in the past. Heart and lungs are normal in appearance. Dental films of the remaining teeth show no evidence of radium poisoning.

(01-266) Born 18 June 1904. Present Health: in fairly good health up to the past six months. Since then she has noticed a decrease of appetite, a

weight loss, easy fatigue, and a knot-like sensation of her upper abdomen at various times in the day. During this time she has been very busy taking care of her husband who is in ill health.

Systems Review. HENT: patient has had headaches all of her life. They were better for five to six years but have been present again in the past three to four years. They tend to be frontal, occipital, occasionally over the vertex, pounding in nature, relieved temporarily by temporal pressure, may last up to two days. Eyes: there was a gradual decrease in vision of the left eye. For the past 29 years she has been able to see nothing except gradations of light and dark through that eye. She occasionally sees double. Ears: no present symptoms. She had a mastoid operation (left) at age 18. Nose: negative. Throat: frequent sore throats. CV: for three to four months she has noted a right antero-lateral aching pain which comes and goes and may be worse with a deep breath when present. She believes this pain was increased after lifting her husband one day. Denies fever. She has an occasional jumping of her heart. She awakens at night with a gasp, with tachycardia, sweating, and apprehension. She notes shortness of breath after two flights of stairs. GI: appetite and weight have decreased as noted above. She frequently has nausea after eating any types of foods in the past four to six months. She has been chronically constipated for four years. She had diarrhea for about a month four years ago which was investigated in the hospital and after bowel x-rays a part of her bowel was resected. No diarrhea since. GU: patient states that she had swelling all over her body as a child, was told she had kidney disease. No further symptoms since, but about once a year she notes a short period of burning and stinging on urination. She usually has two times nocturia. Allergy: negative. Endocrine: negative. NM: no fractures or bony pain. The last three months she has frequently felt light-headed and weak and has fallen frequently. She has not actually fainted in this time but has fainted when she was younger. Habits: she smokes about one pack of cigarettes a day, rarely drinks alcohol, drinks about 12 cups of coffee per day. Takes no medicines regularly at present except Anacin for headaches. Past History: operations - tonsillectomy when young. She had a tumor of her left back removed before marriage, mastoidectomy at age 18, hysterectomy 21 years ago apparently for complications of childbirth. She had a bowel resection four years ago. Illnesses: no rheumatic fever, diabetes, or tuberculosis. She was once put to bed for eight weeks, told she had a heart attack after great feelings of weakness; no chest pain, dyspnea, or ankle edema at that time, no further symptoms. No serious

injuries. Family History: mother is living and fairly well at age 80, father died at age 75 after symptoms of easy choking. He had had tuberculosis when young. No familial history of diabetes, cancer, allergy, or epilepsy. She has three brothers and one sister, all living and well. Marital History: married 32 years. She has seven children living and well. Another child, her first, died at birth. Five of her children are married and each of these have children so that she has twelve grandchildren. Her two younger sons have apparently been mentally retarded, the youngest one did not walk until he was four years old. They are at present in a state hospital. Dental History: patient states her teeth were always soft, but that about 29 years ago they began to have more cavities. She then had extractions of the different teeth gradually over the past five to ten years and has had no teeth at all for ten years. She wears upper and lower plates, complains that the lower plate does not fit at present. Radiation Exposure: patient worked painting watch dials with radium from 25 June to 14 July 1923 at the age of 19. She pointed the brush with her fingers, denied pointing it with her lips. She would notice an occasional glowing of her clothes at night. No other history of radiation exposure. Physical Examination: a well-developed, obese, white woman with a dry cough, weight 183 lbs., height 5'4", BP 124/80, pulse 80 per minute. Skin: normal in texture. Hair: body and scalp hair normal in appearance and texture. No significant lymphadenopathy. HENT: weakness of the left internal rectus muscles. Patient is able to distinguish only light and dark and gross movements with her left eye. Both retina appear unremarkable, both pupils react to light, consensual reflexes appear normal. Nose and Ears: negative. Throat: negative. Patient wears an upper plate, edentulous mandible. Thyroid gland not felt. Chest: resonant, no pulmonary rales. Heart: not enlarged clinically, normal sinus rhythm 84 per minute, A2 greater than P2. Abdomen: liver just palpable under the right costal margin; spleen was not felt; well-healed linear scars from an appendectomy, hysterectomy, and also a well-healed left pararectus scar. Pelvic and Rectal: not done. Extremities: no ankle edema, dorsalis pedis pulses good, prominent veins of the lower legs. CNS: unremarkable, except for the left eye as mentioned above.

Lab. Findings: Urinalysis: sp. gr. 1.025, albumin neg., sugar neg., 8-10 wbc, 0-3 Ca oxalate crystals/HPF. Hematology: wbc 3500, differential P54, L46, rbc normocytic, corr. sed. rate 0.2 mm/hr., hematocrit 41 percent. Blood chemistries: alk. phos. 4.3 units, BUN 16.4 mg percent, sugar 89 mg

percent, Hinton negative. Electrophoresis (grams percent): TP 6.5, alb 4.52, TG 1.97, α1 0.30, α2 0.31, β 0.55, γ 0.81.
X-ray Findings: skeletal series fails to show any evidence of radiation osteitis. Incidental findings are minimal degenerative changes in both knee joints and above the left elbow.

(01-267) Born 1904. Living and in good health. Luminous watch dial painter for 2-3 years starting about 1925 at about age 21. Tipped brush regularly. Married with one child. No physical exam, x-ray, or laboratory work done.

(01-268) Born 15 July 1901. Present Health: was essentially well until December 1958 when she began to have pains in the sternal region of the chest. In January 1959 she first began to notice a swelling in this region. She consulted various physicians, but no definite cause for the pain was found at this time. It is questionable whether there was in fact any objecting swelling in the early stages of this illness, but it was more likely a subjective feeling of pressure or tension in this area. She consulted a doctor in July or August of 1959, at which time there was definite swelling over the manubrium of the sternum near the right sterno-clavicular joint. Hospitalization was advised, and a local resection of tumor mass was done. She made an uneventful convalescence from this first operation although there has been some pain in the region of the swelling for the past 6 months. During the past 6 to 7 weeks, there has been a return of the swelling at the site of the operation in the region of the manubrium sternum and some pain extending from this area to the right axilla. There have been no other symptoms or complaints.
Systems Review: no abnormalities of the eyes, ears, nose, or throat. No history of any swollen glands in the neck or elsewhere. CR: negative except for the pains in the chest noted in the Present Health above. GI: essentially normal in recent years. She used to be troubled with nervous indigestion but not recently; no nausea or vomiting. There have been occasional mild episodes of diarrhea during the past year. GU: normal. Catamenia: menarche at age 16, periods regular until age 45; there have been a few hot falshes but none recently. NM: negative except for pains in the bones of the sternal region as noted above. No skin abnormalities.
Habits: appetite good. There has been no great change in weight during the past year. She sleeps soundly at night and is not kept awake by the

pain in the chest. She does not smoke, no alcohol consumed, minimal amount of exercise at home. Past History: usual childhood diseases but no specific history of scarlet fever, diphtheria, rheumatic fever, allergy, or epilepsy. No history of any mental disorder. Operations: only with present illness. No previous accidents or fractures. Family History: father died at 86, cause unknown; mother died at 83, gangrene of the leg. Eight siblings living and well out of a total of 12. One sister had a sarcoma of the eye at age 5 but no family history of tuberculosis, diabetes, epilepsy, allergy, or mental disorder. Marital History: married in 1919 but has been separated from husband for many years, exact number not known. Two children are living and well, and there were no miscarriages. Dental History: she began to have some trouble with her teeth after the children were born but none at the time of dial painting at period of time before her marriage. During the past 10 to 15 years she has gradually lost more and more of her teeth and now has only 2 remaining of molars. She had several teeth removed approximately 2 years ago. As far as can be made out, there has been no difficulty with healing after extractions. Radiation Exposure: painted watch dials in 1916 at the age of 15 for a period of 6 months at first and then after a one year interval returned to painting again for another 6 months. They were taught to tip the brush in their mouth, and she did this fairly regularly. She remembers some glowing of the hands at night, but none of the hair or clothing.

Physical Examination: a well-developed and nourished woman in no distress but with obvious swelling over the sternum, weight 129 lbs., height 59", BP 138/82, pulse 80 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose: no obstruction. Throat: normal. She wears dentures except for 2 remaining molar teeth in the rear of the mouth. Neck: no cervical adenopathy or palpable thyroid. There is a firm, somewhat tender swelling over the sternum in the region of the right sternoclavicular joint approximately 4 cm in diameter and 2 cm in height. This is dome-shaped and smooth. The skin over this area is somewhat discolored. Well-healed scar from previous operation. Heart and Lungs: normal to auscultation and percussion. Abdomen: soft and relaxed, liver and spleen not felt. Pelvic and Rectal: not done. Extremities: normal. Reflexes: equal and active.

Lab. Findings: not done.

X-ray Findings: small areas of bone resorption in skull vault. These are equivocal and could be venous lakes, + or -. Only 2 teeth remain. Both are molars and one shows expansion of pulp cavity, extensive repaired

caries, + or -. Irregular destruction of manubrium of the sternum. Appearance is consistent with a malignant tumor. The rest of the bony thorax is normal. The heart and lungs appear normal, 5+. Small punched-out areas of bone resorption in both fibulas and tibias less than 1 cm in diameter, 1+ each. Punched-out areas of bone resorption in both humeri, scapulas, and clavicles less than 1 cm in diameter, 1+ each. Small punched-out areas of bone resorption in both radii and ulnae less than 1 cm in diameter, 1+ each. There is a small osteoma in the right frontal sinus. Skull base, spine, pelvis, femurs, feet and ankles, hands and wrists are negative. Impression: advanced (tumor). Total Score 12 T.

(01-269) Born about 1911. Laboratory worker from 1932 to 1933. No physical exam, x-ray, or laboratory work done.

(01-270) Luminous dial painter for 7 to 8 months in 1943. Tipped brush regularly. No physical exam, x-ray, or laboratory work done.

(01-271) Born in 1899. Luminous dial painter for 1 year 8 months starting in 1917 at age 17. No physical exam, x-ray, or laboratory work done.

(01-272) Born about 1888. Chemist for 2-1/2 years starting in 1956 at age 68. No physical exam, x-ray, or laboratory work done.

(01-273) Born 1 March 1907. Present Health: patient considers herself to be in excellent health.
Systems Review. Head: occasional headaches. No epilepsy, no fits, no fainting spells. Eyes: wears glasses all the time; otherwise, no diplopia, etc. Ears: good hearing, no infections, occasional tinnitus. Nose: no epistaxis, good sense of smell. Mouth: no soreness of mouth or tongue; has occasional brief feeling that she cannot swallow. This lasts only a few seconds and has never been serious. Neck: no known goiter, has no particular preference for either hot or cold weather. Breasts: no history of tumors or infections. CR: completely negative. No edema, no dyspnea, no chest pain, no pneumonia, no hemoptysis. No history of hypertension, rheumatic fever, or heart murmur. GI: her appetite is good. Over the years she has been gaining weight slowly and steadily. The only food she cannot eat is cabbage. This causes gas. She says that two years ago she was hospitalized because of a nerve in her stomach. This functioned

in such a way that food would not go down. She had no vomiting and this was eventually cleared with enemas. She has no jaundice. Her bowel movements are irregular; she does not take laxatives. She says that when she has roughage in her diet, she had, on occasion, had a few spots of bright red blood in her stool. The last time this occurred was a few weeks ago. She knows she has hemorrhoids. GU: no infections of the kidney and bladder, no nocturia, no dysuria. Catamenia: menarche occurred at the age of 16; menopause at the age of 48. No vaginal discharge, spotting, or pruritus since that time. Extremities: no known varicose veins, arthritis, rheumatism, or intermittent claudication. Psychiatric history: she says she gets depressed fairly often, is quite nervous and cries fairly easily. Skin: negative. Habits: no alcohol, no tobacco, no medication. Eight hours sleep a night. Past History: operations - none. Serious illnesses: none. Family History: father died at age of 87 of questionable cerebral vascular accident; mother died at age of 85 following gallbladder surgery. A brother died at the age of 62 of cerebral vascular accident. A sister died at the age of 19 of tuberculosis in the glands of her neck. She has one sister who is rather sickly in a nonspecific way, and three brothers who are living and well. There is no family history of diabetes. Marital History: is married, her husband is living. They have had no children and she attributes this to the fact that she says she has a small uterus. Dental History: three years ago had an upper partial plate installed, and ten years ago had a lower partial plate. The remaining teeth are in fair condition she feels, and she sees her dentist infrequently. Radiation Exposure: she worked painting watch dials from 13 March 1924 to 19 March 1924, at the age of 17. Unfortunately, she is unable to recall any details of this.

Physical Examination: patient is a blond, fair-skinned, moderately obese, well-developed, healthy-looking woman who is 52 years of age; height 62.5", weight 158 lbs., BP 126/86, pulse 92. Head - Eyes: pupils equal, react to light and accommodation, extraocular movements negative, fundi negative, slightly myopic. Ears: eardrums intact, hearing acute. Nose: negative. Mouth: partial upper and lower dentures. Throat: negative. Neck: good carotid pulsations. Small thyroid. Breasts: large, no masses or tenderness. Lungs: negative to percussion, good breath sounds, no rales. Heart: not enlarged, normal sinus rhythm, good tone, no murmurs. Abdomen: no scars, not distended, slight RLQ tenderness with deep palpation, no rebound tenderness. No liver, kidneys, or spleen felt. Good femoral

pulsations. Pelvic: not done. Rectal: presence of a few external hemorrhoids confirmed. Digital not done. Extremities: good pedal pulsations, no edema, no joint pathology. Has a blister over the 5th left metatarsal phalangeal joint. Skin: normal. Diagnoses: moderate obesity, myopia, small external hemorrhoids.
Lab. Findings: Urinalysis: sp. gr. 1.015, albumin neg., sugar neg., occ epith. cell, rare wbc. Hematology: wbc 7800, differential P23, L73, E3, M1, rbc normocytic, corr. sed. rate 10 mm/hr., lymphs appear to be of the small mature type, hematocrit 39 percent. Blood chemistries: alk. phos. 4.6 units, BUN 13.7 mg percent, sugar 132 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.3, alb 4.45, TG 1.85, $\alpha 1$ 0.14, $\alpha 2$ 0.38, β 0.60, γ 0.73.
X-ray Findings: skeletal series fails to show any evidence of radium poisoning.

(01-274) Born in 1906. Luminous dial painter from 3 August 1922 to 9 September 1922 starting at age of about 16. No physical exam, x-ray, or laboratory work done.

(01-275) Chemist. No additional information available at present.

(01-276) Born about 1930. Laboratory worker for about 4 years starting in 1945 at age 15. Severe arthritis at present. No physical exam, x-ray, or laboratory work done.

(01-278) Born approximately 1904. Laboratory worker about 1925. No physical exam, x-ray, or laboratory work done.

(01-279) Born 1901. Laboratory worker for 20 years starting in 1928 at age 27. No physical exam, x-ray, or laboratory work done.

(01-280) Born 23 December 1905. Present Health: good, in general. After about six months of symptoms a small duodenal ulcer was found about a year ago. After medical treatment she has had few symptoms since.
Systems Review. HENT: headaches, occasional. Eyes: wears glasses. Ears and Nose: negative. Throat: sore throat once every 1 to 2 years; apparently had a strep throat last year. She has an intermittent sensation of a lump in her throat. CV: no chronic cough; she notes an occasional jump

of her heart. GI: appetite good, weight essentially steady over the past year. She notes frequent belching. A peptic ulcer was discovered as noted in Present Health about 1 to 1-1/2 years ago. She denies melena at any time. GU: no history of dysuria, stones, or infection. Urinary stress incontinence apparently denied. Hysterectomy was done about 9 years ago because of excessive bleeding apparently due to fibroid tumors. She has had no bleeding or discharge since that time. She has had sensations of hot flashes in the past 1 to 2 years. Allergy: negative. NM: no fractures, no bony pain except aches in the fingers and occasionally in the knees, worse in bad weather. The aches may occur at both distal and proximal interphalangeal joints in some fingers. She states that there is some redness and swelling of the fingers and joints in bad weather. Endocrine: after symptoms suggestive of hyperthyroidism and the appearance of a goiter over at least a year the patient had a thyroidectomy about 20 years ago. Since that time she has taken thyroid extract gradually increased to what she states is 5 grains a day, and recently increased from that amount. She has stopped thyroid medication for as long as a month, notes a "bloating" of her body and weight gain at such times. She has denied any change in the texture of her skin or hair and denied other symptoms of hypothyroidism. Habits: she does not smoke, rarely drinks alcoholic beverages. She is not an excessive milk, coffee, or tea drinker. She takes no medicines regularly except thyroid as mentioned above. Preparations she used appears to be Proloid. Past History: operations - appendectomy 22 years ago, thyroidectomy 20 years ago, hysterectomy 9 years ago, cholecystectomy 6 years ago. No other serious illnesses; no serious injuries. Family History: father died at age 55 in an automobile accident; mother died at age 58, exact cause unknown. She had arteriosclerosis and gallbladder disease. Two brothers died with heart attacks, one brother had asthma. Their ages were 50 and 64 years of age. Two brothers are living and well. One cousin had tuberculosis. No known family history of diabetes, cancer, allergy, or epilepsy. Marital History: patient has been married 33 years. She has had 3 children, one of whom died at 22 months of age of scarlet fever and pneumonia; no miscarriages. Dental History: patient has worn full dentures since 1943, wore an upper plate since 1937. She had two teeth extracted at the age of 17. The others began to be extracted when she was about 21 or 22 years old. Radiation Exposure: at the age of 21 from 27 July 1926 to 13 September 1926 she was a radium dial painter. She does not remember pointing the brush with her lips, does remember pointing it occasionally with her fingers. She noted no glowing

of her skin, hair, or clothes at night. She has had no other radiation exposure of this type.

Physical Examination: a well-developed, obese, white female, height 4'11", weight 139-1/2 lbs., BP 124/80, pulse 80 per minute and regular. Skin was fine but of normal texture. The hair was fine in texture; eyebrows appeared diffusely thin. Body hair appeared normal. Lymph: unremarkable. HENT: retinae negative. Extraocular movements normal. Nose: negative. Ears: negative. Throat: tonsils present and enlarged, no signs of infection. She was completely edentulous, wore full upper and lower dentures. There was a well-healed thyroidectomy scar. There was what appeared to be a small nodule where the right lobe of the thyroid would normally be. Chest: unremarkable. Heart: regular sinus rhythm 80 minute, A2 greater than P2. Abdomen: well-healed linear scars of cholecystectomy, appendectomy, and hysterectomy. Liver and spleen not felt. Pelvic: there is some gaping of the urethral opening. The interior vaginal wall was poorly supported. There was some tenderness bilaterally at the vaginal vaults. Rectal: unremarkable. Extremities: no ankle edema, good dorsalis pedis pulses, no deformities. CNS: no delay of relaxation phase, deep tendon reflexes which are equal and symmetrical 1+ except for the ankle jerks which were 2+.

Lab. Findings: Urinalysis: sp. gr. 1.020, albumin neg., sugar 4+, rare epith. cell, few calcium oxalate crystals. Hematology: wbc 4300, differential P58, L30, M3, rbc normocytic, corr. sed. rate 1 mm/hr. hematocrit 45 percent. Blood chemistries: alk. phos. 5.9 units, BUN 15.0 mg percent, sugar 134 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.9, alb 4.63, TG 2.27, α; 0.36, $\alpha 2$ 0.49, β 1.13, γ 1.29.

X-ray Findings: skeletal series shows no definite evidence of radiation osteitis. The following abnormalities are seen: there is hyperostosis frontalis interna. This is of no clinical significance. There is a polyp or mucocele in the left antrum. There are degenerative changes in the joints of the fingers and about the elbows and shoulders, as well as in the dorsal spine. These are all consistent with the patient's age. The heart and lungs appear normal. The cortical outlines of the tibiae and fibulae and to a lesser extent, the fibulae are slightly shaggy. This is particularly true near the lower ends of the tibiae along the lateral aspects. It is believed these changes are apt to be at the site of the attachment of the interosseous ligament. It is doubtful that they are of any significance insofar as radiation osteitis is concerned.

(01-282) Born 3 February 1893. Present Health: reasonably good and has been for many years with the exception of ringing in the ears and variable amounts of arthritis of the back.
Systems Review. Eyes and Ears: no great difficulty except for the tinnitus noted above. Nose and Throat: some postnasal drip and sinus trouble complicated by a deviated septum in his youth. This was eventually repaired. CR: negative. GI: normal. Bowels regular at times but tendency to constipation, no blood in the stools. GU: occasional nocturia and at times marked dysuria at night. NM: arthritis of the spine with lordosis. This was discovered when x-rays were taken 15 or more years ago. Skin: dermatitis of the fingers for over a year approximately 15 years ago. This gradually cleared up with medication. Habits: appetite good. No weight change in recent years. Sleep is variable with episodes of insomnia. Has not smoked for 25 years. Alcohol consumption 2 to 3 drinks per day. Exercise fairly regular. Past History: usual childhood diseases but no specific history of scarlet fever, diphtheria, rheumatic fever, epilepsy, allergy, or mental disorders. Family History: father died of high blood pressure at age 75; mother died at 83 of kidney disease. One aunt and two uncles died of cancer. No family history of diabetes, tuberculosis, mental disorders, or epilepsy. Marital History: married 37 years from 1922 to the present. Wife, age 66, living and well. Two children, ages 35 and 33, living and well, each one having children of their own. Dental History: has had comparatively little trouble with his teeth having lost only 4 or 5 permanent teeth altogether. No trouble with healing after extractions. Several of his front teeth have been capped but the roots are intact. Radiation History: has been in chemical engineering ever since he got out of college. At the age of 23 in 1916 he worked in the processing of radium which meant crystallizing in the order of 100 mg a month for over a year. He continued varied types of processing for a total of 3 years altogether. Physical Examination: a well-developed and nourished, healthy-appearing man of 66 in no apparent distress, weight 183 lbs., height 5'10", BP 162/110, pulse 82 and regular. Eyes: pupils and extraocular movements normal. Throat: negative. Teeth: in good repair, only 5 missing. Neck: no cervical adenopathy or thyroid enlargement. Ears: negative to examination, no growths or deafness by tuning fork. Nose: normal. Heart and Lungs: normal to auscultation and percussion. Abdomen: negative. Liver and spleen not felt, inguinal rings normal. Genitalia: normal except for a hydrocele on the right. Rectal: 2+ enlargement of the prostate, presumably

benign. Hematest negative. Reflexes: equal and active. Extremities: normal. Back shows some lordosis in the lumbar region resulting in limitation of motion on forward bending. Otherwise negative.
Lab. Findings: Urinalysis: sp. gr. 1.005, albumin neg., sugar neg., occ wbc, few epith./HPF. Hematology: wbc 8200, differential P67, L33, rbc normocytic, corr. sed. rate 0.1 mm/hr., hematocrit 45 percent. Blood chemistries: alk. phos. 5.5 units, BUN 18.2 mg percent, sugar 99 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.2, alb 4.65, TG 2.55, $\alpha 1$ 0.32, $\alpha 2$ 0.46, β 0.88, γ 0.89.
X-ray Findings: skeletal series fails to show any evidence of radium poisoning. There is a small area of rarefraction in one of the frontal bones which conceivably could be due to radium necrosis but is not pathognomonic. There is evidence of an old healed fracture at the distal end of the right tibia and fibula with osteoporosis of the leg distal to this point. In the absence of any other evidence of radium intoxication it is believed there is no evidence this is a pathological fracture. Incidental findings are severe degenerative changes in the interphalangeal joints of both hands and the first metacarpal joint of the left hand. Dental films of the remaining teeth and the alveolar processes show no evidence of radium damage.

(01-283) Born 10 November 1895. Present Health: good and has been in recent years except for a tendency to arthritis and an itching dermatitis over one ankle for many years.
Systems Review. Eyes: wears glasses for reading; right eye somewhat worse than the left and she thinks vision has changed for the worse somewhat in the past 4 to 5 years. Ears: increasing deafness particularly in the left ear. Ten years ago she began to have moderate amount of ringing in the ears which has persisted to the present time. No difficulty with nose or throat. No history of any swollen glands in the neck or elsewhere. CR: occasional mild transitory precordial pains not necessarily related to exertion. She has noticed some dyspnea in the past year. GI: essentially negative. No history of any blood in the stools. GU: occasional nocturia only. Catamenia: menarche at age 11, periods regular until age 46; some hot flashes for a few years, none recently. She has had no flow since menopause. NMS: has had arthritis in the left knee and right big toe for 2 or 3 years. Tendency to bursitis in the right shoulder 7 years ago. Occasional headaches, not severe. No paresthesias. Skin: itching dermatitis in the left ankle for over 30 years persumably related to varicose veins, only temporary

relief from steroid ointment. Habits: appetite good. Weight has dropped off 5 lbs with vigorous dieting. Sleeps fairly well, 6 or 7 hours per night; does not smoke, no alcohol consumed. Past History: usual childhood diseases, but no specific history of scarlet fever, diphtheria, or rheumatic fever. Denies any allergy, epilepsy, or mental disorder. Operations: gallbladder, about the age of 34 followed by some jaundice. No further difficulties at that time. No accidents, injuries, or fractures. Family History: father died at 71, question of heart disease; mother died at 80 of intestinal obstruction. Four siblings living and well. One died one year ago, six died in infancy. No familial history of cancer, diabetes, or tuberculosis. No allergy, epilepsy, or mental disorder in the family so far as is known. Marital History: married for 31 years until husband died 14 years ago. Five children living and well, all married. Ages are 43, 37, 36, 33, and 22. Two died in infancy. Dental History: has lost 8 to 9 teeth altogether. Lost the first tooth at approximately age 20, 5 were removed about 5 years ago. Radiation Exposure: worked for a period of approximately 1 year in 1917 at the age of 22 filling light pulls. There was a lot of dust and excess paint floating around in the atmosphere. She does not remember hands or clothing glowing at night. No definite or known ingestion of this luminous paint.

Physical Examination: a well-developed, nourished, healthy-appearing woman, height 489", weight 160 lbs., BP 140/80, pulse 82 and regular. Eyes: pupils and extraocular movements normal. Ears: slight deafness, left greater than right. Nose and Throat: normal. Remaining teeth in good state of repair. Neck: no cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: soft and relaxed. Liver and spleen not made out. Well-healed scar from cholecystectomy to right of midline. Pelvic and Rectal: not done. Reflexes: equal and active. Legs show marked varicose veins on the left with scaling dermatitis over the lateral aspect of the left ankle and some just below the left knee. Varicose veins and accompanying dermatitis were the only pathology found on physical examination at this time.

Lab. Findings: Urinalysis: sp. gr. 1.015, albumin neg., sugar neg., 6-10 rbc, occ wbc/HPF. Hematology: wbc 7200, differential P62, L38, rbc normocytic, corr. sed. rate 0.2 mm/hr., hematocrit 42 percent. Blood chemistries: alk. phos. 5.6 units, BUN 15.9 mg percent, sugar 114 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.9, alb 3.74, TG 3.17,

α1 0.35, α2 0.64, β 0.98, γ 0.19.
X-ray Findings: skeletal series shows no evidence of radiation osteitis. The abnormalities seen consist of degenerative changes in the dorsal and lumbar spine consistent with the patient's age; an old healed fracture of the left 7th rib. The osteitis pubis and calcification in the region of the both greater tuberosities. Dental films of the remaining teeth and the alveolar processes show no evidence of radium damage.

(01-284) Born 7 March 1892. Present Health: fairly good considering the fact that he had an attack of coronary thrombosis 4 years ago and a small retinal hemorrhage in the left eye 3 months ago.
Systems Review. Eyes: retinal hemorrhage which came on rather rapidly with blurring of vision in the left eye has shown no progression and, if anything, has improved slightly. Otherwise no disturbances. Vision in the right eye; no other eye abnormalities. Ears: negative. Nose and Throat: slight sinus trouble. Neck: no history of any swollen glands. CR: had attack of definite coronary thrombosis 4 years ago when he was laid up for 8 to 10 weeks. During the next 2 years he had varying degrees of angina and dyspnea. He did not actually retire until 2 years ago from his position as office manager in a radium and uranium company. Eventually decided that this job was too hectic and since retiring has had little or no angina, has not felt the need of taking any nitroglycerin, has had no more palpitation which had been treated by quinidine up until 2 years ago. He takes no medication now whatsoever. GI: normal except for occasional gas in the stomach. Bowels reasonably regular, no blood in the stools. GU: nocturia 2 to 3 times a night, otherwise normal. NM: had some bursitis in shoulders 1 to 2 years ago, none recently. No headache or paresthesias. Skin: no abnormalities. Habits: appetite good. Weight has gone up a few pounds in the last year. Sleeps fairly well. Smokes 20 to 30 cigarettes per day. Alcohol consumption 2 to 3 drinks per day. Exercise minimal. Past History: uncertain as to what childhood diseases he has had. Feels that he has not had diphtheria, scarlet fever, rheumatic fever, allergies, mental disorder, or epilepsy. Operations: tonsillectomy and submucous resection only. Hospitalized for a week to 10 days during the course of his attack of coronary thrombosis 4 years ago. No history of any accidents, injuries, or fractures. Family History: father died at 67 of diabetes; mother died at 49 of toxic goiter. He had six siblings, one of whom died of cancer at the age of 58. No other family history of cancer.

No other members of the family have diabetes. No tuberculosis, allergy, epilepsy, or mental disorder known. Marital History: married 45 years to the present time. Wife, age 67, living and well. One son, age 44, living and well with one child. No other children by choice. Dental History: has lost only 5 teeth to the present time in spite of extensive dental repair work. No trouble with healing of the sockets after extraction. Radiation Exposure: at the age of 51 in 1943 he took a position with a radium and uranium company and divided his time between the office and the processing division. At one time he was handling as much as 5 grams of radium per week. The exact nature of his work with radium is somewhat difficult to determine.

Physical Examination: a healthy, vigorous-appearing man of 67, weight 169 lbs., height 57", BP 200/90, pulse 78 and regular. Eyes: pupils contracted but equal. React poorly to light and accommodation. Fundi not visualized because of constriction of pupils. Extraocular movements normal. Ears: negative. Nose and Throat: normal. Teeth: show extensive repair. Neck: no cervical adenopathy or thyroid enlargement. Heart: normal to auscultation and percussion. No murmurs heard. Lungs: clear and resonant. Abdomen: soft and relaxed. Liver and spleen not felt, inguinal rings normal. Genitalia: normal. Prostate shows minimal enlargement without masses. Hematest negative. Extremities: normal. Reflexes: equal and active.

Lab. Findings: Urinalysis: sp. gr. 1.013, albumin neg., sugar neg., rare wbc/HPF, 0-2 epith. cells, few amorphous urate crystals. Hematology: wbc 12,000, differential P55, L39, E5, M1, rbc normocytic, corr. sed. rate 13 mm/hr., hematocrit 48 percent. Blood chemistries: alk. phos. 4.7 units, BUN 18.5 mg percent, sugar 110 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.7, alb 4.39, TG 2.31, $\alpha 1$ 0.40, $\alpha 2$ 0.68, β 0.89, γ 1.34.

X-ray Findings: skeletal series shows no evidence of radiation osteitis. Incidental findings are: bilateral congenital fusion of the proximal ends of the radius and ulna. Extensive degenerative spurring of the dorsal spine. There is a questionable small soft tissue mass in the right superior mediastinum (this could be produced possibly by some of the unusual spinal spurring.). Small patches of atelectasis in the left lower lobe. Slight cardiac enlargement without evidence of failure. Dental films of the remaining teeth and the alveolar processes show no evidence of radium damage.

(01-285) Born 31 August 1900. Present Health: good and has been in recent years.
Systems Review: no abnormalities of the eyes. Ears: some tinnitus and questionable deafness of the left ear for several years. No abnormalities of the nose or throat other than a slight tendency to dryness of the throat in cold weather. Neck: no history of any swollen glands. CR: negative. GI: some indigestion with greasy foods. Bowels tend to be constipated, takes laxatives nearly daily. No history of any blood in the stools. Some tendency to intermittent hemorrhoids in the past year. GU: negative. Catamenia: menarche at age 12, periods regular until menopause at age 50. No flow since that time. Considerable difficulty with hot flashes at first, none in recent years. NM: intermittent pains in the region of the right upper arm, right thigh, and lumbar spine. No headaches of consequence. No paresthesias. No skin abnormalities. Habits: appetite good. Weight has come down approximately 10 lbs. during the past year with dieting. Sleep only fair. Smokes 4 to 5 cigarettes daily. Alcohol consumption minimal. Gets moderate amount of exercise at home. Past History: usual childhood diseases and she also believes she had scarlet fever and diphtheria. No history of rheumatic fever, allergy, epilepsy. Questionable history of a mild nervous breakdown at age 38 or 39 at the time of the birth of her youngest child. Operations consist of mastoidectomy right ear at age 5, tonsillectomy age 34, removal of gland from neck sometime during childhood, operation on left foot and right ankle for hammertoe and exostoses of the ankle bones approximately 5 years ago. No history of any fractures, accidents, or injuries. Family History: father died at 61 of pneumonia; mother,age 79, living and well. Two siblings, one of whom died of heart disease at age 49; the other, age 61, living but believed to have cancer of the throat. No familial history of diabetes, tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married 40 years to the present time, husband age 64, living but has diabetes. Three children, ages 39, 32, and 31. Between them they have 3 children. No history of any stillbirths or miscarriages. Dental History: patient kept most of her teeth until approximately the age of 50 at which time she had all of the upper teeth and all but 4 of the lower teeth removed. She has worn dentures since that time. No difficulty with healing of the sockets after extractions. Radiation Exposure: at the age of 23 from 17 September 1923 to 22 September 1923 she was employed as a dial painter. She denies any putting of the brush or radium paint in her mouth. She does not remember any luminescence of the clothing or hands.

Physical Examination: a robust, healthy-appearing woman of 60, weight 165 lbs., height 62", BP 140/90, pulse 82 and regular. Eyes: pupils and extraocular movements normal. Ears: some deafness in the left ear, well-healed mastoid scar behind right ear. Nose: normal. Teeth: only 4 remaining, wears upper and lower plates. Neck: scar right anterior cervical region, site of removal of gland. Chest: transient rales at both bases. Heart: normal to auscultation and percussion, no murmurs heard. Breasts: normal female, no masses felt. Abdomen: liver and spleen not felt. Pelvic and Rectal: not done. Reflexes: equal and active. Extremities: scar on left foot and right ankle, site of previous operation.
Lab. Findings: Urinalysis: sp. gr. 1.020, albumin neg., sugar neg., moderate amount mucus, many Ca oxalate crystals/HPF, 2-6 epith. cells/HPF, 0-1 wbc/HPF. Hematology: wbc 9300, differential P60, L40, rbc normocytic, corr. sed. rate 21 mm/hr., hematocrit 44 percent. Blood chemistries: alk. phos. 6.3 units, BUN 22 mg percent, sugar 218 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.4, alb 4.33, TG 3.07, $\alpha 1$ 0.33, $\alpha 2$ 0.61, β 0.86, γ 1.27.
X-ray Findings: skeletal series is negative for radiation osteitis. Left mastoid process is sclerotic probably due to previous infection. There is calcific bursitis near the greater tuberosity of the right humerus. Degenerative changes are present in the cervical, dorsal, and lumbar spine, knee joints, tarso-metatarsal joint of the right foot, and both hands.

(01-286) Born about 1918. In 1942-1943 was treated with Thorotrast injection. During injection, material leaked out of needle into neck tissues. Began to have severe neck pain in 1958 requiring frequent medication to control pain. Treatment with CaEDTA in 1959 did not result in mobilization of Thorotrast. Neck resection done in 1960. No information available at present on physical exam, x-ray, or laboratory work.

(01-287) Born 7 April 1908. Present Health: good and has been in recent years except for mild diabetes discovered 3 years ago. This is fairly well controlled by 2 Orinase tablets a day. Urinalyses show 0 to 2+ sugar in recent months.
Systems Review: no abnormalities of the eyes, ears, nose, or throat. No history of any swollen glands of the neck or elsewhere. CR: negative. GI: some heartburn and gas, otherwise no complaints. Bowels regular without laxatives, no history of any blood in the stools. GU: approximately

1 month ago she was told she had some albumin in the urine, but this cleared up with treatment. Urine is allegedly normal at the present time. Nocturia 1 to 2 times per night, otherwise g.u. system negative. Catamenia: menarche at age 13, periods regular until age 49. No flow of any sort since that time. Some difficulty with hot flashes at the present time. NM: occasional headaches but no joint pain or paresthesias. No skin abnormalities. Habits: appetite good. No weight change with diet. Sleeps well. Does not smoke or drink, exercise mostly consists of work at home and factory. Past History: usual childhood diseases. No specific history of rheumatic fever, diphtheria, allergy, epilepsy, or mental disorder. Operations: removal of left tube and an ovary at age 25. No history of any fracture, accident, or injury. Family History: father, age 76, living and well; mother,age 74, living but multiple nonspecific complaints. Five siblings living and well. One grandmother, 1 aunt, and an uncle had cancer on mother's side. One aunt living with diabetes on mother's side. No family history of tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married 21 years to the present time, husband, age 46, living and well. Two children, age 19 and 16, living and well. No other children or pregnancies by choice. Dental History: patient always troubled to a certain extent with cavities since late teens. In her twenties these cavities became more serious and numerous. In her early thirties she began to lose her teeth, many of them breaking off at the gum line. Finally by the age of 49 all of the teeth had been removed, and she has worn full upper and lower dentures since that time. Sockets always healed without incident after teeth were extracted. Radiation Exposure: painted radium watch dials from 22 November 1927 to 14 June 1928. Patient states emphatically that at the time she was doing this work they did not use a brush but instead used a metal pen. Never put pen in her mouth but was exposed to dust in the process of scraping paint off old dials and hands. Remembers glowing of clothing and hair at night after work.

Physical Examination: a well-developed and rather overweight woman of 51, weight 178 lbs., height 65-1/2", BP 144/84, pulse 88 and regular. Eyes: pupils, extraocular movements, and fundi normal. Ears: negative. Nose and Throat: normal. Completely edentulous, wears full upper and lower dentures. Neck: shows no palpable thyroid or glandular enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: liver and spleen not felt, no tenderness

or other masses. Pelvic and Rectal: not done. Extremities: normal except for moderate bilateral hammertoe. Reflexes: equal and active. No skin abnormalities.
Lab. Findings: Urinalysis: sp. gr. 1.023, albumin neg., sugar 3+, 0-4 epith. cell/HPF, 0-3 wbc/HPF. Hematology: wbc 6900, differential P58, L42, rbc normocytic, corr. sed. rate 15 mm/hr., hematocrit 43 percent. Blood chemistries: alk. phos. 5.2 units, BUN 19.0 mg percent, sugar 306 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.7, alb 4.02, TG 3.69, $\alpha 1$ 0.35, $\alpha 2$ 0.80, β 0.99, γ 1.55.
X-ray Findings: skeletal series shows no evidence of radiation osteitis.

(01-288) Born 22 August 1896. Present Health: good at the present time except for a tendency to hypertension which has been present for several years for which she takes medication.
Systems Review. Eyes: tendency to irritation of the lids with a scratchy feeling. This is intermittent. Not present at this time. Ears: tendency to itching of the external canals. Nose and Throat: negative. No no history of any swollen glands in the neck or elsewhere. CR: occasional dyspnea but no chest pain or cough. GI: negative. Bowels regular without laxatives. Has had some rectal bleeding from time to time, last episode a week ago. GU: negative. Catamenia: menarche at age 16, periods regular until age 48. Some hot flashes but no flow since that time. NM: some arthritis of the fingers only. No headaches or paresthesias. No skin abnormalities. Habits: appetite good. Slight weight reduction with dietary effort. Sleep is fair only. Does not smoke or drink, exercise consists of housework and walking. Past History: usual childhood diseases, but no specific history of scarlet fever, diphtheria, rheumatic fever. No allergy, epilepsy, or mental disorder.. Operations: none. No injuries, fractures, or hospitalizations. Family History: father died, age 72, after operation on the prostate; mother died, age 59, of cerebral vascular accident. Three siblings living and well. One sibling died at 50 of arteriosclerotic heart disease. Another brother died of heart disease at age 59. No family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married 39 years to the present time. Husband, age 64, living and well. Three children, ages 37, 35, and 27; one child born 34 years ago died in childhood. No stillbirths or miscarriages. Dental History: had poor teeth from early twenties on. These rapidly deteriorated so that only the roots were left

by the time all teeth were removed at age 35. No trouble with healing of the sockets after extractions. Radiation Exposure: painted luminous watch dials from 4 August 1926 to 16 August 1926. At that time she and all the other girls were taught to point the brush in their mouth. She remembers no luminescence of hair or clothing.
Physical Examination: a well-developed, well-nourished, healthy-appearing person, weight 147 lbs., height 61", BP 170/ 110, pulse 84 and regular. Eyes: pupils and extraocular movements normal. Marked AV nicking and tortuosity of the retinal vessels. Nose and Throat: normal. Completely edentulous, wears full upper and lower dentures. Neck: no enlargement of the glands. Question of palpable thyroid. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: soft and relaxed. Liver and spleen not felt. Pelvic and Rectal: not done. Extremities: normal. Reflexes: equal and active.
Lab. Findings: Urinalysis: sp. gr. q.n.s., albumin neg., sugar neg., large amount mucus, 0-5 epith. cells, many wbc/HPF. Hematology: wbc 7000, differential P55, L43, M2, rbc normocytic, corr. sed. rate 25 mm/hr., hematocrit 42 percent. Blood chemistries: alk. phos. 6.8 units, BUN 19.4 mg percent, sugar 175 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.5, alb 3.91, TG 3.59, $\alpha 1$ 0.49, $\alpha 2$ 0.70, β 1.01, γ 1.39.
X-ray Findings: skeletal series shows no abnormalities aside from some degenerative changes consistent with her age in the spine and some in the peripheral joints. There is no evidence of radiation osteitis with 2 possible exceptions. The mid shaft of the right humerus shows some punched-out areas of rarefaction, one of which is slightly over 1 cm in diameter. These changes are not present in either the upper or lower ends of the bone where radiation changes are usually seen. On the left side, there are very few small punched-out areas of rarefaction in the upper third of the shaft. None of these is over 1 cm in diameter. The upper and lower ends of the left humerus are also normal. Conclusion: the changes in the right humerus could be on the basis of radiation osteitis. The same is true on the left. If so, this gives a total score of 3 which would make this a very minimal case. However, it is believed that the changes are on the basis of age rather than radiation.

(01-289) Born 14 December 1899. Present Health: good and has been except for hypertension and some nervous tension of many years' duration. For.

this she is taking oral medication in the form of one pill daily and an injection, type undetermined, every 2 to 3 weeks.
Systems Review: no abnormalities of the eyes, ears, nose, or throat. No history of any swollen glands of the neck. CR: slight dyspnea on exertion and some swelling of the ankles at the end of the day after sitting all day long at work. This is more noticeable in summer than in winter. GI: occasional mild heartburn, otherwise no difficulty. Bowels regular without laxatives. No history of any blood in the stools. GU: negative. Catamenia: menarche at age 13, periods regular until age 52. None since that time. One dilatation and curettage at age 53, negative for any malignancy. NM: occasional headaches and some night cramps of the legs. No skin abnormalities. Habits: appetite good. Weight has remained about the same. Sleeps soundly at night, does not smoke, occasional alcohol in social use. Exercise mostly involves housework. Past History: usual childhood diseases but no specific history of scarlet fever, diphtheria, rheumatic fever. No history of any allergy, epilepsy, or mental disorder. Only operation was D and C as noted above. No fractures or hospitalizations. Family History: father died at age 63, cause not known; mother died at age 83 of cancer of uterus. There are 9 siblings, 2 of whom are living and well. One brother living with heart disease. One died of meningitis. Another died of heart disease. The remainder of the siblings died in early childhood or infancy. Marital History: married for the first time for a period of 20 years from 1920 to 1940. Second marriage from 1943 to the present time, 17 years. Present husband, age 60, living and well. Three children by first marriage, now ages 41, 35, 33. There are also 2 miscarriages between these living births. Dental History: has 8 of her own teeth left at the present time. There was a gradual loss of her permanent teeth from the time she was in her teens up to the present. There was no difficulty with healing after extractions. Radiation Exposure: she painted clock dials from 11 July 1919 to 24 January 1921. She remembers pointing the brush in her mouth although she does not remember any glowing of the hands or clothing at night.
Physical Examination: a well-developed and nourished, healthy-appearing woman of 60 in apparent good health, weight 175 lbs., height 65", BP 265/120, pulse 88 and regular. Eyes: pupils and extraocular movements normal. Rather marked AV nicking on funduscopic examination. Ears, Nose, and Throat: negative. Remaining teeth in good repair. Neck: no cervical adenopathy. There is questionable enlargement of the thyroid although

this is not definite. Heart: slight enlargement by percussion but no murmurs are heard. Lungs: clear. Breasts: normal female, no masses felt. Abdomen: soft and relaxed. Liver and spleen not felt. Pelvic and Rectal: not done. Extremities: normal. No varicosities. Good dorsalis pedis pulsation. Reflexes: equal and active.
Lab. Findings: Urinalysis: sp. gr. 1.010, albumin neg., sugar neg., 6-8 epith. cells/HPF, 5-10 wbc/HPF. Hematology: wbc 7700, differential P68, L30, M4, rbc normocytic, corr. sed. rate 30 mm/hr., hematocrit 42 percent. Blood chemistries: alk. phos. 3.1 units, BUN 19.7 mg percent, sugar 152 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.8, alb 3.78, TG 3.01, $\alpha 1$ 0.37, $\alpha 2$ 0.54, β 0.81, γ 1.29.
X-ray Findings: skeletal series shows no evidence of radiation osteitis. One small rarefaction in the lower end of the right tibial shaft is a change due to aging rather than radiation. The only abnormalities seen are some degenerative changes in the spine and some of the peripheral joints consistent with the patient's age. Dental films of the anterior remaining teeth show no radiation damage. There are numerous cavities, most of which are repaired.

(01-290) Born 7 May 1906. Present Health: poor and has been for many years. She has been seen intermittently at a clinic for the past 14 years. At the present time she is having treatments about once a month. She has had a multiplicity of complaints and operations, the most serious of which in the last few years consist of a hysterectomy in October 1957, a partial gastrectomy in July 1958, and a cholecystectomy in July 1959. She has been troubled with varying degrees of cystitis for the past 11 years.
Systems Review. Eyes: normal. Ears: occasional dizziness. Nose: variable amounts of epistaxis. No throat abnormalities. Neck: some difficulty in swallowing and question of slight amounts of regurgitation of food. This has occurred during the past two months. CR: occasional precordial pains but no cough at the present time. GI: since her partial gastrectomy 2 years ago she has had only occasional nausea and vomiting, though recently there has been this question of regurgitation of food. She has very little abdominal pain now. Bowels tend to be loose, thought to be due to presence of diverticuli in the large bowel. She is on a very strict diet consisting mostly of meat, potatoes, butter, and cream. She takes a moderate amount of milk of bismuth for correction of the diarrhea. She also takes vitamin pills, injections of liver and B12 every one to two

weeks to maintain her blood at a proper level. GU: very frequent dysuria and incontinence of urine by day and night both. On occasions she has noticed both pus and blood in the urine. For this condition she takes pro-banthine tablets from time to time. Catamenia: menarche at age 10, periods regular until age 27 when periods stopped not to commence again until age 50 when she had almost continuous bleeding. This culminated in the hysterectomy at age 51. NM: sprained left ankle in 1958, dislocated left thumb in December 1959. This last injury was very slow in healing. Headaches were frequent and severe until she had the gastrectomy in 1958 and since then much less difficulty. Skin: stated to have no abnormalities but does admit to allergy to wheat, aspirin, milk, eggs, and chocolate. Ingestion of these foods may cause a dermatitis. Habits: appetite is good, weight has come up from 87 to 105 lbs. during the past year. The greatest weight was 185 lbs. 5 to 6 years ago. Sleeps poorly. Does not smoke or drink. Past History: usual childhood diseases but no specific history of scarlet fever, diphtheria, rheumatic fever. She is allergic to aspirin and other items of food as noted above. No history of any epileptic seizures. Had some type of mild mental disorder for which she took tranquilizers for several months. Operations: patient states that she has had a total of 31 operations in all, of which the following represent a partial sample: namely, appendectomy, several operations for cysts on or about the ovary, several operations on the rectum, a sympathectomy of the cervical region. In all she has had no fractures or serious injuries. Family History: father died at 85, cancer of the mouth. Mother, age 89, living and well. Two sisters living and well, one sister died of ruptured gallbladder. No other family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married 35 years to the present time. Husband, age 60, living with tendency to epilepsy. Two children, age 34 and 33. No miscarriages or other pregnancies. This was not by choice. Dental History: teeth in fairly good condition, has 21 of her own teeth remaining. There was some difficulty in healing after extractions of teeth, the last extraction taking place 2 weeks ago. Radiation Exposure: painted dials in 1920 at the age of 14 from June to September for 4 summers, then transferred to another company where she worked at chipping and scraping of dials. She does not remember much tipping of the brush in her mouth; she does remember some glowing of her hair and clothing at night. Physical Examination: an alert, healthy-appearing woman of 57, height

62", weight 104 lbs., BP 156/96, pulse 82 and regular. Eyes: show a slight ptosis of the right lid with constriction of the right pupil Left eye normal. Ears: negative. Nose and Throat: normal, remaining teeth in good repair. Neck: no palpable thyroid or glandular enlargement. Heart and Lungs: normal except for a soft 1+ systolic murmur best heard at the apex. Abdomen: multiple well-healed scars at sites of previous abdominal operations. Liver and spleen not felt. Pelvic and Rectal: not done. Extremities: essentially normal. Reflexes: equal and active.
Lab. Findings: Urinalysis: sp. gr. insufficient, albumin neg., sugar neg., rare epith. cell, 0-3 wbc/HPF. Hematology: wbc 7000, differential P63, L35, M2, corr. sed. rate 11 mm/hr., hematocrit 37 percent. Blood chemistries: alk. phos. 6.4 units, BUN 12.0 mg percent, sugar 105 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.5, alb 4.08, TG 3.47, $\alpha 1$ 0.44, $\alpha 2$ 0.57, β 0.89, γ 1.57.
X-ray Findings: skeletal series shows no evidence of radiation osteitis. Both humeri and one tibia and fibula show rather small spongy areas of radiolucency. These, in view of the negative findings elsewhere are, it is believed, changes due to aging and not to radiation osteitis. The posterior third of the right second rib is missing. It is assumed this was a surgical procedure, possibly surgery on the sympathetic nervous system. Two metal clips are seen in the abdomen on the left side at the level of L1, again, presumed due to previous surgery. No other abnormalities are seen.

(01-291) Born 8 September 1910. Present Health: poor because of heart disease and diabetes. She is taking 20 units of insulin once a day. She takes medication, presumably a vasodilator, for angina pectoris. She has been told that she has a diaphragmatic hernia.
Systems Review. Eyes: some blurring of vision lately associated with a low grade discharge from the lids. She has been subject to occasional earaches but has had none for the past six months. Nose: some sinus drip and hay fever in the summer. No severe sore throats of consequence. Neck: no known swollen glands in the neck or elsewhere. CR: has been subject to precordial and substernal pain on exertion for several years. These pains are relieved by vasodilators. A diagnosis of heart disease was established in March of 1959. She has some cough. She has quite marked dyspnea on exertion as well as angina. GI: she has been subject to morning vomiting off and on for 10 years. She had a cholecystectomy over 10 years ago which did not relieve this condition. Many x-rays have

taken. The only positive finding of which she knows is that of the diaphragmatic hernia. She is on a strict diet because of this and the diabetes. Bowels only fair, occasional streaks of blood. GU: some nocturia 2 to 3 times per night, otherwise negative. Catamenia: menarche at age 11. Periods regular until age 44, no flow since that time. Some hot flashes at first but none lately. NM: some pain in the knees, occasional headaches. Skin: has had outbreaks of psoriasis for most of her life. At the present time these skin lesions are doing fairly well. Past History: usual childhood diseases, but no specific history of scarlet fever, rheumatic fever, diphtheria. Only allergy is tendency to hay fever. No epilepsy, or mental disorder. Operations: gallbladder removed 10 years ago and a large layer or accumulation of adipose tissue removed from the anterior abdominal wall approximately 15 years ago. No history of any fractures, accidents, or injuries. Family History: father and mother died, cause undetermined. She was brought up by foster parents. Nothing is known of siblings or family history of disease. Marital History: married 30 years from 1929 to 1959 when husband died of heart disease. One son,age 29, living and well. No other pregnancies. This was not by choice. Dental History: began to have trouble with her teeth when she was 16. All the upper teeth were removed by age 19. Lower teeth were removed by age 21. Radiation Exposure: painted watches from 25 July 1928 to 26 November 1928 at the age of 19. There was no tipping of the brush in the mouth, but she did notice glowing of the hair and clothing when she got home at night.

Physical Examination: a well-developed, nourished woman in no apparent distress at this time, weight 158 lbs., height 5'1-1/2", BP 112/78, pulse 82 and regular. Eyes: pupils and extraocular movements normal. Fundi not well visualized. Ears: negative. Nose and Throat: normal. Mouth: wears full upper and lower dentures. Neck: no palpable thyroid or adenopathy. Heart: only questionable enlargement by percussion. No definite murmurs heard at this time, rhythm regular. Lungs: clear and resonant. Abdomen: shows scars, well-healed, from previous cholecystectomy and lipectomy. Inguinal rings normal. Pelvic and Rectal: not done. Reflexes: sluggish response bilaterally. Extremities: negative. Skin: many psoriatic areas over the extremities and back of the left ear.

Lab. Findings: Urinalysis: sp. gr. 1.015, albumin neg., sugar 2+, rare epith. cell/HPF. Hematology: wbc 7700, differential P63, L35, E1, rbc normocytic, corr. sed. rate 2 mm/hr., hematocrit 41 percent. Blood

chemistries: alk. phos. 2.2 units, BUN 19.2 mg percent, sugar 100 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.5, alb 3.78, TG 2.73, α1 0.37, α2 0.66, β 0.81, γ 0.89.
X-ray Findings: skeletal series shows no evidence of radiation osteitis. There is thickening of the internal table of the frontal bone, so-called hyperostosis frontalis interna, but this is of no clinical significance. There are degenerative changes in the dorsal spine consistent with the patient's age and similar changes about the knees and first metatarsal phalangeal joints of the feet, as well as of some of the joints of the fingers. The heart and lungs are normal in appearance. Conclusion: except for mild degenerative changes, the skeletal survey is normal. The patient is edentulous.

(01-292) Born about 1903. Died 1930. Luminous dial painter from 1919 to 1922 starting at about age 16. Married, 2 children. X-rays 2 months before death showed osteogenic sarcoma of right ilium, osteogenic sarcoma of right orbit, and areas of radiation osteitis in the skull. Autopsy confirmed diagnosis of multiple primary sarcomas.

(01-293) Born 6 January 1911. Present Health: good at the present time, and has been in recent years. Last illness was operation 3 years ago - see below.
Systems Review: no significant abnormalities in connection with the eyes, ears, nose, or throat. No history of any swollen glands of the neck or elsewhere. CR: some dyspnea only. GI: negative except for constipation. No blood in the stools at any time. GU: negative. Catamenia: menarche at age 18, periods were always irregular since onset, often no more than 2 or 3 times per year. Periods continued to be irregular until panhysterectomy was done 3 years ago at the age of 46. She had only rare hot flashes following this operation. NM: occasional bursitis in right shoulder and some intermittent pains in both knee joints, right greater than left. Occasional headaches, mostly on the top of the head. This is mostly after episodes of severe nervousness. No paresthesias. No skin abnormalities. Habits: appetite good. Weight has remained the same in the past few years. Sleeps soundly at night. Does not smoke, no alcohol consumed, exercise variable. Past History: usual childhood diseases. No specific history of scarlet fever, diphtheria, or rheumatic fever. No definite allergies, no epilepsy, or mental disorder. No accidents, injuries, or

fractures. Only operation was panhysterectomy in 1956, uneventful recovery. Family History: father died at 77 of arteriosclerotic heart disease, mother, age 86, living with arthritis. Two siblings living and well. No family history of diabetes, tuberculosis, cancer. No allergy, epilepsy, or mental disorder in the family. Marital History: married for 28 years until June 1959 when husband died at the age of 69 of heart disease. There were no pregnancies of any sort. This was not by design. Dental History: has lost about 14 teeth at the present time. She always had difficulty with cavities, principally due to neglect. No trouble with healing of sockets after extractions. Radiation Exposure: from 16 July 1924 to 3 October 1924 she painted luminous watch dials. She does not remember whether she tipped the brush in her mouth or not. She is inclined to believe that she did not.
Physical Examination: an extremely obese but otherwise healthy-appearing woman of 49, weight 258 lbs., height 65", BP 120/86, pulse 88 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Remaining teeth in good repair, wears partial upper and lower dentures. Neck: no cervical adenopathy or thyroid enlargement. Heart and Lungs: normal to auscultation. Abdomen: could not be palpated with accuracy due to extreme obesity and large panniculus. Pelvic and Rectal: not done. Reflexes: diminished to absent, poor dorsalis pedis pulsations in both feet. Varicose veins of the left leg. Hair on scalp somewhat sparse but no other specific signs of hypothyroidism.
Lab. Findings: Urinalysis: sp. gr. 1.020, albumin neg., sugar neg., 0-2 epith. cell/HPF, 0-2 wbc/HPF. Hematology: wbc 7600, differential P64, L32, E2, M2, rbc normocytic, corr. sed. rate 20 mm/hr., hematocrit 36 percent. Blood chemistries: alk. phos. 3.1 units, BUN 16.6 mg percent, sugar 142 mg percent, Hinton negative. Electrophoresis (grams percent): TP 7.5, alb 3.91, TG 3.58, $\alpha 1$ 0.34, $\alpha 2$ 0.71, β 0.97, γ 1.56.
X-ray Findings: skeletal series is negative for radiation osteitis. There are degenerative changes present in the dorsal and lumbar spine, knee joints, and elbow joints.

(01-294) Born 19 January 1912. Present Health: good and has been in recent years. Only illness she remembers was a virus infection which lasted for about a week a few months ago.
Systems Review. wears glasses with change of prescription approximately every 2 years. Ears: occasional tinnitus which cleared up without treat-

ment. Nose and Throat: normal. No history of any swollen glands of the neck or elsewhere. GI: negative. Bowels tend to be constipated and tendency to bleeding hemorrhoids with constipation. This has been checked on several occasions by her physician. GU: nocturia 2 to 3 times per night only. Catamenia: menarche at age 11, regular until hysterectomy at age 24 because of an infection and tumorous uterus. Prior to this she had a salpingectomy and oophorectomy on one side. Had hot flashes for approximately 3 years after the hysterectomy. NM: negative except for frequent occipital headaches. Cause undertermined, wonders if it could be migraine. Skin: small eczematous area on right buttocks which recurs from time to time during the past 3 years. Habits: appetite good. Weight has remained the same in recent years. Sleeps soundly at night, does not smoke, no alcohol, exercise at work and at home. Past History: usual childhood diseases. No specific history of rheumatic fever, diphtheria, scarlet fever. No allergy, epilepsy, or mental disorder. Operations: had a cholecystectomy at age 18 prior to the oophorectomy and hysterectomy noted above. Also had irrigation of the kidneys at age 33 for question of kidney stones. No accidents, injuries, or fractures. Diet: complete in all respects including dairy products, milk, butter, cheese, fruit, vegetables, and meat. Family History: father died at age 64 of a cancer; mother died at age 32 in childbirth. Four siblings living and well. No other family history of cancer. No family history of diabetes, tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married for 32 years at the present time, on 10 April 1928. Husband, aged 51, living and well. One child, aged 31, has always been mentally retarded. Dental History: only 4 teeth left at the present time. Began to lose her teeth in her late teens. All of the upper teeth removed by age 28. The rest of the teeth were gradually lost by age 45 except for the 4 remaining lower teeth. No trouble with healing after extractions. Radiation Exposure: painted watch dials from 1 August 1927 to 2 August 1928 at the age of 15. Denies any pointing of the brush in the mouth. Does not remember any luminescence of the hair or clothing.

Physical Examination: a well-developed, nourished woman of 48, weight 154 lbs., height 62", BP 146/100, pulse 84 and regular. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Four teeth only remaining; wears a full upper plate. Neck: questionable palpable thyroid. This is not definite. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt.

Abdomen: scars from previous operations. Pelvic and Rectal: not done. Extremities: small varicosities on the lower leg. Reflexes: equal and active.
Lab. Findings: Urinalysis: sp. gr. 1.005, albumin neg., sugar neg., 0-4 epith. cells/HPF, 0-4 wbc/HPF. Hematology: wbc 7700, differential P50, L57, E2, M1, rbc normocytic, platelets normal, corr. sed.rate 11 mm/hr., hematocrit 41 percent. Blood chemistries: alk.phos. 6.0 units, BUN 21 mg percent, sugar 101 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.8, alb 4.25, TG 2.55, $\alpha 1$ 0.30, $\alpha 2$ 0.50, β 0.84, γ 0.91.
X-ray Findings: skeletal series is negative for radiation osteitis. There are degenerative changes in the cervical, dorsal, and lumbar spine. There is a small cyst-like rarefaction in the left femoral neck, probably a bone cyst.

(01-295) Born 16 November 1911. Present Health: good and has been in recent years.
Systems Review: no abnormalities of the eyes, ears, nose, or throat. No history of any swollen glands in the neck or elsewhere. CR: negative except for slight ankle edema. However, she states this swelling in the ankle more marked on the right than the left has been present intermittently since an operation for varicose veins 7 to 8 years ago. GI: negative. Her bowels are regular, no history of any blood in the stools. GU: negative. Catamenia: menarche at age 14, periods regular until hysterectomy at age 36. Following this she had hot flashes for a period of 2 or 3 years, also suffered from low blood pressure and anemia. NM: tendency to arthritis of the fingers only. No headaches of consequence. No skin abnormalities. Habits: appetite good. There has been some weight gain in recent years. Sleeps well at night, does not smoke, no alcohol, exercise at home and at work. Past History: usual childhood diseases. No specific history of scarlet fever, diphtheria, or rheumatic fever. No allergies, epilepsy, or mental disorder. Operations as noted above: hysterectomy 13 years ago, stripping operation for varicose veins 7 to 8 years ago. No fractures, accidents, or injuries. No other hospitalizations. Diet: has been adequate throughout with milk, vegetables, fruit, meat, etc. Family History: father, aged 75, living and well; mother, aged 73, living and well. Six siblings all living and well. No family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married 18 years to the present time on 31 August 1941. Husband, age 49, living and well. Four children, ages 17, 16, 15, and 13. Second

and third children had question of heart disease at birth. It has cleared up subsequently. Dental History: has lost all but 4 teeth during the past 20 years. Began having trouble while in her teens and then gradually had a few out at a time. No trouble with healing after extractions. Radiation Exposure: painted watch dials from 29 July 1927 to 10 October 1927 at the age of 16. Did not remember whether she tipped the brush in her mouth or not. Did not remember any luminescence of the hair or clothing after work. Physical Examination: a well-developed, nourished, rather overweight woman of 48, weight 168 lbs., height 60", BP 112/72, pulse 78 and regular. Eyes: pupils and extraocular movements normal Ears: negative. Nose and Throat: normal. Teeth: all missing except for lower front teeth. Question of slight enlargement of thyroid. No signs of thyrotoxicosis. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: negative except for scar from hysterectomy. Liver and spleen not felt. Pelvic and Rectal: not done. Reflexes: equal and active. Extremities: scars from varicose vein operation with area of induration, right calf, possibly a localized phlebitis. Some hirsutism of face and extremities.
Lab. Findings: Urinalysis: sp. gr. 1.007, albumin neg., sugar neg., rare epith. cell/HPF. Hematology: wbc 6500, differential P61, L38, E1, rbc corr. sed. rate 15 mm/hr., hematocrit 39 percent. Blood chemistries: alk. phos. 2.8 units, BUN 17 mg percent, sugar 108 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.4, alb 3.98, TG 2.42, $\alpha 1$ 0.27, $\alpha 2$ 0.42, β 0.73, γ 1.00.
X-ray Findings: skeletal series is negative for radiation changes.

(01-296) Born 8 October 1908. Present Health: good and has been in recent years. She remembers no illnesses at all other than an occasional upper respiratory infection or influenza. She has lost no time from work because of illness in the last 2 years.
Systems Review: no abnormalities of the eyes, ears, nose, or throat. No history of any swollen glands of the neck or elsewhere. CR: negative. GI: normal. Bowels regular without laxatives. No history of any blood in the stools. GU: negative. Catamenia: menarche at age 13, periods regular until age 47. She had some hot flashes for a few months, then no difficulty. NM: some pain in the region of the right hip for a period of a month a year or so ago. This was relieved by the extraction of a decayed tooth. No headaches or paresthesias. Skin: occasional mild itching

dermatitis of the left lower abdomen during the past two years. Dietary History: has been normal at all times, had plenty of dairy products, fruit, meat, vegetables in childhood and through early teens. No particular likes or dislikes in respects to food. Past History: usual childhood diseases. No specific history of scarlet fever, diphtheria, rheumatic fever. No allergy, epilepsy, or mental disorder. No accidents, injuries, operations, or fractures. Hospitalized for birth of children only. Family History: father died at age 72 of heart disease, mother died at age 62 of cerebral accident. There were 12 siblings in all; 3 died in infancy, one died of cerebral accident, one died of pneumonia. Six siblings living and well. No family history of cancer, diabetes, tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married on 4 September 1935 for 25 years to the present time. Husband, age 49, living and well. Two children, age 24 and 19. Older child married with 2 children. No other pregnancies. This was by choice. Dental History: patient states that her teeth were always poor. She has lost approximately 14 teeth to the present time. She has also a great deal of trouble with cavities and receding gums. This has been a gradual process over the years. There was no trouble with healing of the sockets after extractions. Radiation Exposure: painted watch dials from 8 November 1927 to 5 December 1927 at the age of 19. At this time there was no tipping of the brush in the mouth. She was very careful to avoid any unusual or unnecessary exposure to the paint. She remembers no glowing of the hair or clothing at night after work.
Physical Examination: a well-developed and nourished woman of 51, weight 110 lbs., BP 138/86, pulse somewhat rapid, rate 110. Eyes: pupils and extraocular movements normal. Ears: negative. Nose and Throat: normal. Teeth in poor state of repair, many missing. Gums remarkably recessed. Neck: no palpable thyroid or other glandular enlargement. Heart and Lungs: normal to auscultation and percussion. Breasts: normal female, no masses felt. Abdomen: negative. Liver and spleen not made out. Inguinal rings normal. Pelvic and Rectal: not done at patient's request. Extremities: normal. Reflexes: equal and active. Good pulsation of dorsalis pedis vessels.
Lab. Findings: Urinalysis: sp. gr. 1.007, albumin neg., sugar neg., rare epith. cell/HPF. Hematology: wbc 9100, differential P71, L27, M2, rbc normocytic, corr. sed. rate 13 mm/hr., hematocrit 44 percent. Blood chemistries: alk. phos. 4.5 units, BUN 15 mg percent, sugar 78 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.8, alb 4.52, TG

2.28, α1 0.35, α2 0.57, β 0.67, γ 0.69.
X-ray Findings: skeletal series is negative for radiation osteitis. There are degenerative changes in the cervical, dorsal, lumbar spine.

(01-297) Born 25 December 1901. Present Health: good and has been in recent years. She tells of having had two nervous breakdowns requiring institutional care, the first in 1949 for one year, and the second for 2 or 3 months in 1955. Other than this she has been essentially well. Systems Review: no abnormalities of the eyes except that she wears glasses. Ears: she has had known perforations of both drums since childhood following an attack of diphtheria. The right ear continued to discharge small amounts from time to time. No discharge from the left ear. She has had moderately severe deafness in both ears, but the deafness is greater on the left than the right. She believes that there has been no progression of the deafness in recent years. Nose: normal. Throat: negative except for tendency to sore throats. None of these have been severe. No history of any swollen glands in the neck since childhood. CR: some dyspnea on exertion. She has known that she has had a murmur of the heart for the past 20 years, cause undetermined. Otherwise no c.r. difficulties. GI: negative. Bowels regular without laxatives. No history of any blood in the stools. GU: negative except for recent irritation and inflammation in the region of the urethra for which she has been treated by her family physician during the past 2 weeks. Catamenia: menarche at age 15, periods regular until approximately age 51, followed by severe hot flashes at first. She still has some trouble with hot flashes at the present time. NM: no joint symptoms of any kind. Only rare headaches, no paresthesias. No skin abnormalities. Habits: appetite good. Weight has remained the same in recent years with diet, sleeps fairly good, smokes 25 cigarettes daily, alcohol consumption - 2 drinks per day. She gets a moderate amount of regular exercise. Diet: has included practically all the usual food sources although she feels that there may have been some deficiency in fruits and fruit juices particularly in her early teens and her twenties. Past History: she had the usual childhood diseases as well as scarlet fever and diphtheria. No known history of rheumatic fever. She believes she had a tendency to diabetes about 14 years ago that cleared up with diet. Has never taken insulin. No allergy except to orange juice and chicken. No history of any epilepsy. Two episodes of nervous breakdown as noted above. No operations except tonsillectomy in childhood. Frac-

tured her left ankle 4 years ago when she stumbled over a chair. Only hospitalizations were for the nervous breakdowns as noted above. Family History: her father died at 67 of heart disease; mother died at 56, cause not definite but possibly due to cancer of the stomach. Two siblings living and well. One cousin with diabetes. No family history of tuberculosis, allergy, epilepsy, or mental disorder. Marital History: married for the first time in 1918 at the age of 17 when she ran away from school. This terminated in a divorce 6 weeks later. There were no pregnancies resulting from this marriage. Second marriage was on 3 July 1944. This terminated in divorce in February 1958. No pregnancies by this second marriage. This was by chance and not by design. Dental History: has only 2 of her own teeth left at the present time. She began to have trouble with her teeth in her early twenties. She never had any great tendency to cavities, but the teeth showed a tendency to loosen up and gradually drop out. Over the years she lost one after the other. By age 50 she had a complete upper denture and a partial lower denture. Radiation Exposure: painted watch dials from 7 June 1921 to 20 October 1921 and then again from 15 October 1923 to 5 November 1923. At that time they were all taught to point the brush in the mouth which she did regularly while she was working. She remembers no luminosity of hair or clothing. She does remember occasionally painting her fingernails when going out on dates.

Physical Examination: spare, well-developed woman of 59 in apparent good health but with deafness, weight 122 lbs., height 62", BP 118/80, pulse 78 and regular. Eyes: pupils and extraocular movements normal. Ears: perforations of both drums with some discharge in the right ear canal. There is definite deafness in both ears, most marked on the left. Nose: normal. Teeth: all missing except for 2 lower teeth. Neck: just barely palpable thyroid. Heart: slight enlargement by persussion. There is a loud systolic murmur heard best in the aortic and apical area. No definite diastolic component heard at this time. Breasts: normal female, no masses felt. Abdomen: soft and relaxed. Liver and spleen not made out. Pelvic and Rectal: not done at patient's request. Extremities: normal except for mild hallux valgus. Reflexes: equal and active.

Lab. Findings: Urinalysis: sp. gr. 1.010, albumin neg., sugar neg., 3-5 epith. cells/HPF, 0-3 wbc/HPF. Hematology: wbc 7600, differential P70, L28, M2, rbc normocytic, platelets normal, hematocrit 43 percent. Blood chemistries: alk. phos. 6.1 units, BUN 27 mg percent, sugar 88 mg percent, Hinton negative. Electrophoresis (grams percent): TP 6.8, alb 4.23, TG 2.57, $\alpha 1$ 0.28, $\alpha 2$ 0.48, β 0.79, γ 1.02.

X-ray Findings: there are punched-out areas of rarefaction less than 10 cm in diameter scattered throughout the vault and coarsening of the trabecular pattern, score 2+. Small punched-out areas are present longitudinally arranged in both tibias less than 1 cm in diameter, score 1+ each. There are minimal areas of rarefaction less than 1 cm in diameter in the right forearm, score 1+. There are areas of rarefaction in the left forearm, one one of which is over 1 cm in diameter, score 2+. There are degenerative changes in the dorsal and lumbar spine. All other areas are negative for radiation changes.

(01-299) Born in 1896. Luminous dial painter between 1917 and 1918 at about age 21. No physical exam, x-ray, or laboratory work done.

(01-301) Born in 1904. Received "Ra" injections in 1926 at about age 22 for low blood count. Married from 1928 to present. No physical exam, x-ray, or laboratory work done.

(01-302) Born about 1900. Received $RaCl_2$ injections, totalling 400 μc, in 1928. Fracture of femur, failed to heal after multiple bone grafts. Infection developed and resulted in disarticulation of hip.

(01-303) Born 26 November 1919. Instrument dial painter from 1940 to 1942 starting at about age 20. No physical exam, x-ray, or laboratory work done.

(01-305) Born 1925. Chemist in radium refinery 1947 to present. No physical exam, x-ray, or laboratory work done.

(01-306) Chemist in radium refinery. No physical exam, x-ray, or laboratory work done.

(01-307) Chemist in radium refinery. No physical exam, x-ray, or laboratory work done.

(03-003) Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(03-004) Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(03-005) Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(03-006) Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(I.Da.) See case (I.Da.) M.I.T. progress report (AECU-3774) May 1958.

(I.Ja.) See case (I.Ja.) M.I.T. progress report (AECU-3774) May 1958.

(09-001) Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

(09-002) Additional details on this case may be obtained from Dr. Asher J. Finkel, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois.

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