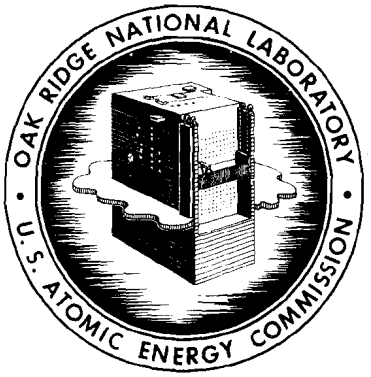

OAK RIDGE NATIONAL LABORATORY

operated by

UNION CARBIDE CORPORATION

for the

U.S. ATOMIC ENERGY COMMISSION

UNION CARBIDE

ORNL - TM - 148

83

SERVICES OF THE CLINICAL LABORATORY OF THE HEALTH DIVISION JULY 1, 1960, THROUGH JUNE 30, 1961

NOTICE

ORNL-TM-148

Contract No. W-7405-eng-26

SERVICES OF THE CLINICAL LABORATORY OF THE HEALTH DIVISION

July 1, 1960, Through June 30, 1961

T. A. Lincoln, Director
G. F. Zanolli, Assistant Director

DATE ISSUED

APR 16 1962

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
operated by
UNION CARBIDE CORPORATION
for the
U. S. ATOMIC ENERGY COMMISSION

Summary

The activities of the clinical laboratory of the Health Division during July 1, 1960, through June 30, 1961, are reviewed in this report. Part I consists of a listing of the routine schedule for the performance of the various laboratory tests and examinations. To assist in the interpretation of these tests, Part II contains an outline of the basic techniques employed and the screening levels used to determine which results must be reviewed by a staff physician. The percentage of significant positive results and "normal" ranges for ORNL employees are listed in Part III.

Part IV is a special study of the routine screening serum-cholesterol determinations which have been performed during this time period. Six and one-half percent of ORNL men between the ages of 30 and 64 had screening cholesterol levels over 300 mg %, and 33% had levels over 250 mg %. The cholesterol level was apparently not related to age but tended to go up with increasing amounts of overweight and was higher in men with hypertension. The distribution of levels in ORNL men 40 to 50 years old was similar to those found in studies done in five other American cities.

A discussion of the selection of tests, the percentage return of significantly positive results at ORNL, and a comparison with several published studies are included in Part V. Unfortunately, because of differences in population sizes and compositions as well as the use of slightly different criteria, only superficial comparisons were possible. There were no startling differences.

The industrial hygiene activities of the Laboratory are reviewed in Part VI, and Part VII contains a tabulation of the numbers of the various tests, both routine and special-request types, which have been performed.

This report will be of value to persons at ORNL interested in the activities of the Health Division clinical laboratory and will be of interest to industrial physicians in other units of the Union Carbide Corporation and possibly to the Atomic Energy Commission, as well as to private physicians requesting work by this laboratory. The Health Division staff will use the report as a reference manual.

Contents

Part I
Screening Program

Each Laboratory employee is invited approximately once a year (12 to 15 months) to come to the Health Division for certain basic clinical laboratory tests. This multiphasic testing program is designed to screen employees for abnormalities which may be indicative of hidden or known diseases which need attention. These laboratory tests either supplement the complete physical examination given by the staff physician or, for the younger age group, provide an interval screening between these examinations.

The routine schedule for the performance of the laboratory tests and complete physical examinations is outlined below. Those performed about once a year or otherwise, as indicated, are marked with an "*A*". Those which are done either at the time of the interview physical examination (preliminary) or at the time the employee reports for work (preplacement) are marked with a "*P*". A "*T*" indicates those which are done at termination of employment.

1. Complete blood count. *A, P, T.* – Includes hemoglobin, hematocrit, white blood cell count, and differential count of the WBC's.
2. Urinalysis. *A, P, T.* – Includes specific gravity, albumin, sugar, and microscopic examination of sediment.
3. Blood pressure. – *A, P, T.*
4. Height and weight. – *A, P, T.*
5. Tuberculin skin test. – *A, P.* Discontinued after first positive reaction.
6. Chest x ray. *A, P, T.* – Yearly if 30 years of age or older or if less than 30 and have a positive tuberculin skin test or previous abnormal chest x ray. Employees less than 30 who have a negative tuberculin skin test may have a chest x ray if they desire, but it is not routinely recommended.
7. Vision. *A, P, T.* – Every three years (at time of complete examination) until age 40, then annually. A screening type of visual field examination is made annually on all employees over 45.
8. Audiogram. *A, P, T.* – Every three years on all employees under 45, and annually thereafter.
9. Electrocardiogram. *A, P.* – At or near age 35 and again at 40 (at time of complete examination) and every year after age 45. If tracing is abnormal it is repeated yearly regardless of age.
10. Serum cholesterol. *A.* – Each year on males 45 or older. Every three years on males between 35 and 45.
11. VDRL. *A, P.* – Every third year at time of complete examination until age 45 then again at or near 50, 55, and 60. The test is repeated annually on all individuals having positive serologies and on all Negro employees.
12. Blood type and Rh factor. *P.*
13. Complete physical examination by staff physician. *A, P, T.* – Every three years until age 45, then annually.

The results of all but the audiogram, blood type, Rh factor, and visual-field screening are coded on mark sense cards (see Figs. 1, 2, and 3). Coding is performed by laboratory personnel or, in case of the chest x ray and electrocardiogram, by other clerical staff.

The laboratory tests precede the examination by the physician in order to have all results available to him. The time interval varies from two weeks to two months, depending on scheduling problems. Signifi-

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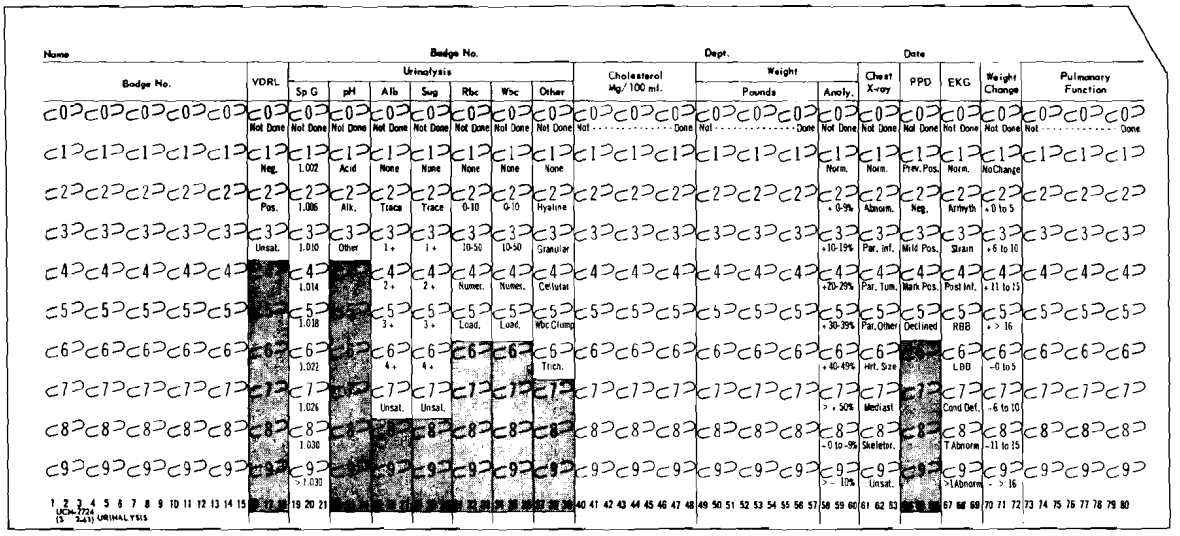

Fig. 1. Urinalysis and Miscellaneous Tests Mark Sense Card (yellow).

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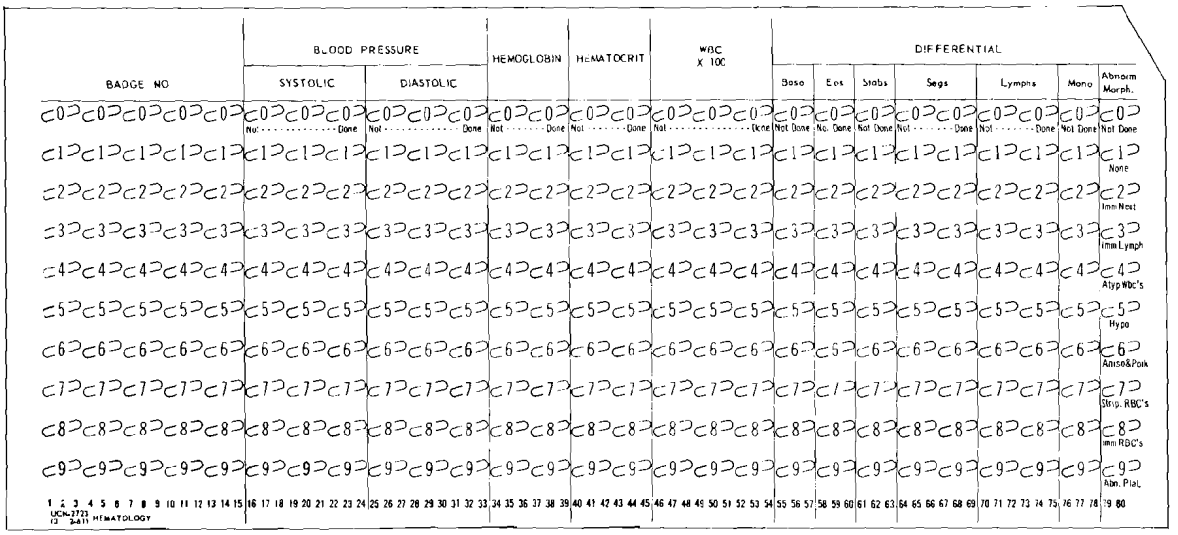

Fig. 2. Hematology and Blood Pressure Mark Sense Card (pink).

cantly abnormal laboratory results are reviewed by a physician as soon as they are available. If he is sufficiently concerned he will call the employee in for a special examination or repeat test. If the abnormality is questionable or no immediate examination seems necessary, the investigation of the results will be deferred until the complete examination. No written reports on either abnormal or normal test results are made to the patient except under special circumstances. Copies of reports are mailed to the family physician if specifically requested. The electrocardiogram and chest x ray will be loaned to the family physician, but the responsibility for their return is the employee's, not the physician's.

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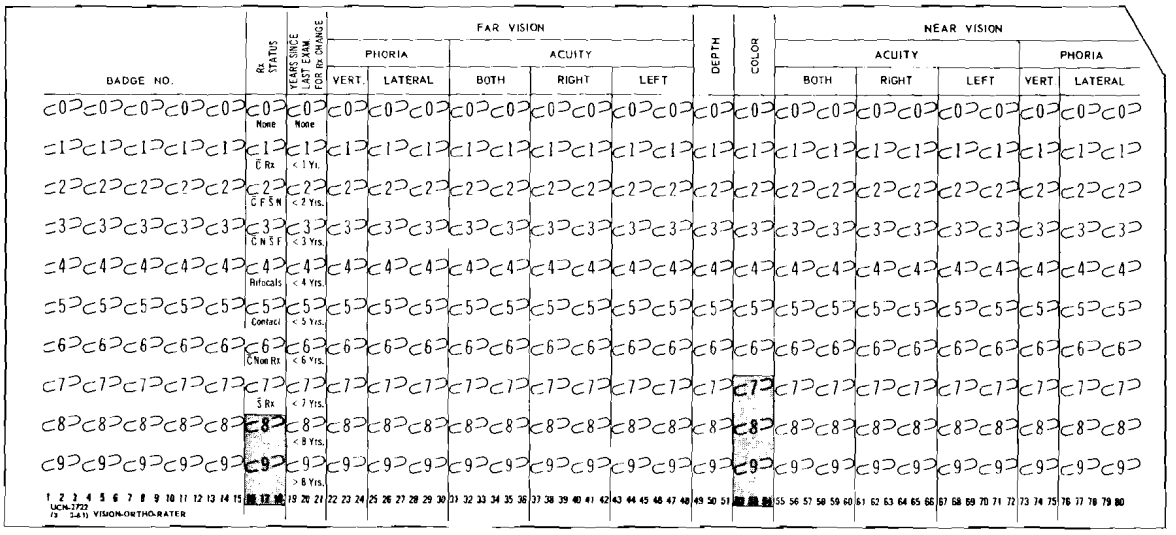

Fig. 3. Vision Mark Sense Card (green).

Part II
Techniques and Screening Levels for Periodic Tests

The multiphasic testing program of the ORNL Health Division consists of a group of measurements which are made on individuals when they are interviewed for employment or when they report for work, periodically thereafter, and finally when they terminate. The routine frequency of the performance of these tests has been covered in Part I. The X-Ray Department, Clinical Laboratory, and Nursing Staff perform these services. Below is an outline of the basic techniques employed and the screening levels used to determine which results must be promptly reviewed by a staff physician.

COMPLETE BLOOD COUNT

A complete blood count (CBC) includes the following measurements and examinations:

HEMOGLOBIN DETERMINATION

The oxyhemoglobin method of Sheard and Sanford[1] is used to determine grams percent hemoglobin. The determinations are read on the Coleman Jr. spectrophotometer. A calibration curve is prepared, using a stabilized human-whole-blood hemoglobin standard.[2] This curve is verified monthly.

Normal range of values (established elsewhere) with this method: male, 14 to 18 gm %; female, 11.5 to 16 gm %.

ORNL Screening Range. – If there is less than 12 gm %, all such reports are referred immediately to a staff physician for interpretation and disposition.

MICROHEMATOCRIT

Capillary heparinized tubes are filled with blood, centrifuged for 5 min and read on the Adams microhematocrit reader. Normal range of values:[3] male, 40 to 54% (average 47%); female, 37 to 47% (average 42%).

ORNL Screening Range. – Male, $<40\%$ or $>55\%$; female, $<35\%$ or $>50\%$.

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[1] C. S. Sheard and A. H. Sanford, "A Photo-Electric Hemoglobinometer. Clinical Applications of the Principles of Photo-Electric Photometry to the Measurement of Hemoglobin," *J. Lab. Clin. Med.* 14, 558 (1929).

[2] Hemotral, Clinton Laboratories, Los Angeles, California.

[3] From information compiled by the Clay-Adams Company and furnished with their microhematocrit equipment.

WHITE BLOOD CELL COUNT (WBC)

The count is made by use of the standard dilution pipette and the Neubauer counting chamber and is reported as the number of white blood cells per mm^3 of whole blood. Normals according to Wintrobe:[4] 5000/ml to 10,000/ml, with an average of 7000/ml.

ORNL Screening Range. – 4000/ml to 12,000/ml.

EXAMINATION OF STAINED BLOOD SMEAR

The smear is stained with Wright's stain, a careful microscopic examination of 100 consecutive white cells is made and a differential count performed. Cell identification and nomenclature of Diggs[5] is used. The red cells are examined for abnormal morphology.

ORNL Screening Range. – Abnormal percents of cell types based on normals given by Diggs are shown below.

1. All reversals in segmented neutrophil and lymphocyte ratio.
2. All atypical and immature cell findings.
3. Over 10% eosinophils.
4. Abnormal morphology of erythrocytes.
5. Noticeable increase or decrease of thrombocytes.

URINALYSIS

The urinalysis consists of a description of the appearance of the specimen, the specific gravity, the pH, and glucose and protein determinations. A microscopic examination is made of the sediment of 15 ml of the specimen that has been centrifuged for 5 min at 1000 to 2000 rpm.

The pH, glucose and protein values are screened with "Combistix" (Ames Company, Incorporated, Elkart, Indiana) reagent strips. A positive glucose test is confirmed with "Clinitest" (Ames Company). A positive protein is confirmed by the Kingsbury, Clark, Williams, and Post procedure[6] (sulfosalicylic acid reagent and visual comparison with standards).

ORNL Screening Level. – Any positive result. The microscopic examination of the urine sediment has been standardized in order to estimate the numbers of red or white blood cells per high-power field (440X). The following numbers are used for coding on mark sense cards.

1. None.
2. 0 to 10 by actual count.
3. 10 to 50 by actual count.

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[4] M. M. Wintrobe, *Clinical Hematology*, 4th ed., p 226, Lea and Febiger, Philadelphia, 1956.

[5] L. W. Diggs, D. Sturm, and A. Bell, *The Morphology of Human Blood*, W. D. Saunders, Philadelphia, 1956.

[6] F. B. Kingsbury *et al.*, "Procedure for Sulfo Salicylic Acid Reagent Test for Urine Protein," *J. Lab. Clin. Med.* 11, 981 (1926).

4. More than 50 but less than 300 is reported as "numerous."
5. A completely packed microscopic field is reported as "loaded" (count probably above 300).

Casts and other formed elements are reported as being present, but no attempt is made to code the approximate number. This is done in the report sent to the physician. The formed elements coded include the hyalin, granular, and cellular casts. WBC clumps and trichomonas organisms are also included in this group for coding convenience.

ORNL Screening Levels. – (1) Red and white blood cells – any number greater than 10 per high-power microscopic field (440X). (2) All findings of casts, WBC clumping, and trichomonas organisms.

BLOOD PRESSURE MEASUREMENT

The blood pressure is recorded with the patient in the sitting position, with the manometer at the approximate level of the patient's heart. The diastolic pressure is recorded at the disappearance of all sound.

ORNL Screening Level. – 150/90 or more.

HEIGHT AND WEIGHT MEASUREMENT

Height and weight are measured with the patient in his street clothes and with shoes but without a coat and with all tools or other heavy articles removed from the pockets. The technician estimates the frame size by examining the breadth of the wrist and determines the percentage over- or underweight by using the Preludin weight calculator provided by the Geigy Pharmaceutical Company. The ideal weight with this convenient and rapid calculator is approximately the same as the midpoint for the range for each body frame of the table of ideal weights published by the Metropolitan Life Insurance Company.[7]

ORNL Screening Level. – Ten percent or more loss without satisfactory explanation (i.e., diet, etc.).

TUBERCULIN SKIN TEST

The intracutaneous test of Mantoux is used, employing the purified protein derivative (PPD) of Seibert.[8] Tuberculin purified protein derivative is obtained from Parke, Davis and Company, Detroit, Michigan. The intermediate test strength dose[9] is given. The test is read 72 hr following the injection.

ORNL Screening Level. – All conversions from a negative to a positive test.

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[7] "New Weight Standards for Men and Women," *Statistical Bulletin* (Metropolitan Life Insurance Company) 40, 1 (November–December 1959).

[8] Florence B. Seibert, "Tuberculin Purified Protein Derivative," *Am. Rev. Tuberc.* 44, 9 (1941).

[9] As recommended by the National Tuberculosis Association.

CHEST X-RAY METHOD

A standard 72-in. postero-anterior exposure of the chest is performed, using the 14 by 17 in. Buck Cassette with Patterson par-speed intensifying screens and Eastman Kodak Royal Blue film. The faster film reduces the radiation exposure by 50%. The gonad shield manufactured by Amrad Specialties, Daly City, California, is routinely used.

ORNL Screening Level. – All films are reviewed by our consultant radiologist, Dr. R. P. Ball, Oak Ridge, and abnormal films are reviewed by a staff physician.

VISION TESTS

A vision test is performed for both corrected and uncorrected vision at the time of the preplacement and termination physical examinations. Corrected vision only is checked during the periodic examination.

The acuity and phoria for both near and far vision, the depth perception, and the color perception are measured using the Ortho-Rater tester of the Bausch and Lomb Company.

The visual-field examination is made with the Harrington-Flocks Multiple Pattern Visual Field Screener of the Jenkel-Davidson Company, San Francisco, California.

A brief history of the employee's prescription status is recorded with each vision test. This history includes a description of the use of glasses (for near vision only, far vision only, bifocals, contact lenses, etc.).

ORNL Screening Levels. – The screening levels cover an extreme range of values as related to normal visual skills. The levels are this wide because all vision tests are reviewed by a physician at the time of the physical examination. A screening level has been established to prevent overlooking abnormal vision tests on employees who may fail to report for the physician's examination.

Visual acuity: 20/30 Snellen and greater.

Phoria, vertical: Left hyperphoria with a greater deviation than 1.6°. Right hyperphoria with a greater deviation than 1.1°.

Phoria, lateral: Extreme limits of esophoria and exophoria as measured by the machine.

Depth perception: Less than 50% as measured by the machine.

Color perception: Inability to distinguish red-green color.

Visual field: Any defect in visual field.

HEARING TEST (AUDIOGRAM)

The Rudmose automatic audiometer is used. This machine records decibel loss of hearing as indicated by the patient at frequencies of 500, 1000, 2000, 3000, 4000, and 6000 cps. Several readings for each frequency are recorded from which an average decibel loss is estimated. All audiometry is performed in a soundproof standard audiometric testing room made by the Industrial Acoustics Company of New York City.

A brief history of the employee's noise experience, work area, and job description, subjective loss of hearing, URI or other symptoms, and ear disease is recorded with each audiogram. AMA percentage hearing loss is also calculated.

ORNL Screening Level. – Reports which show a 40-decibel loss or greater at 4000 cps, or a 30-decibel loss or greater at all other frequencies are referred to a staff physician.

ELECTROCARDIOGRAM

The Sanborn Viso-Cardiette, model 100 electrocardiograph is used. Twelve leads are taken: standard limb leads I, II, III; unipolar limb leads AVR, AVL, AVF; and chest leads V-1, V-2, V-3, V-4, V-5, and V-6. The tracing is mounted and becomes a permanent part of the employee's medical record.

To enable us to code abnormal results on IBM cards the following categories are used: (This code is unsatisfactory and is being revised.)

1. Normal
2. Arhythmia
3. Strain
4. Post infarction
5. Right bundle branch block
6. Left bundle branch block
7. Conduction defect
8. T-Wave abnormality
9. >1 Abnormality

ORNL Screening Level. – All tracings are reviewed by our consultant cardiologist, Dr. Joseph Acker, Knoxville, and abnormal tracings are reviewed by a staff physician.

CHOLESTEROL DETERMINATION

The method of Pearson, Stern, and McGarack,[10] which uses direct colorimetry without saponification is employed. Cholesterol is separated by glacial acetic acid from the globulins to which it is bound, and total cholesterol is determined by the Lieberman-Burchard reaction (acetic anhydride and sulfuric acid).

The blood specimen is drawn when the employee comes to the laboratory for the rest of his laboratory tests, and he need not be in a fasting state. The serum is separated and stored in the refrigerator (approximately – 15°C) until 20 samples accumulate. The optical density of the solution is measured on the Coleman Jr. spectrophotometer, and the mg % value of cholesterol is read from a calibration curve. The color which develops is sufficiently stable to allow the various steps in the analysis to be performed on the entire batch of 20 samples at one time. For an accuracy control on each set of 20 tests, a cholesterol control serum[11] is always included.

ORNL Screening Level. – >250 mg %.

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[10] S. Pearson, S. Stern, and T. H. McGarack, "A Rapid, Accurate Method for the Determination of Total Cholesterol in Serum," *Anal. Chem.* 25, 813 (1953).

[11] Normal Clinical Chemistry Control Serum, Hyland Laboratories, Los Angeles, California.

VDRL

The Venereal Disease Research Laboratory test for syphilis is used. The blood specimen for this determination is sent to the State of Tennessee Department of Public Health Laboratory, Knoxville, Tennessee.

ORNL Screening Level. – All positive tests are reviewed by a staff physician.

BLOOD TYPE AND Rh FACTOR

Dade anti-A and anti-B blood-group serums are used. The Rh factors are determined using Dade anti-D, anti-CD, and anti-DE serums. (Dade Reagents, Incorporated, Miami, Florida.)

Part III
Analysis of Results:
Percentage of Significantly Positive Tests and ORNL Normal Range Values

The results of the laboratory tests done during the several health evaluation programs have been analyzed in an attempt to better define the "normal" range of values among ORNL employees and to estimate the percentage return of significantly positive results.

This normal range of values will be helpful in interpreting the significance of individual routine tests. A better appreciation of normal ranges is necessary before clinical laboratory studies of groups of workers who have chronic exposures to small amounts of toxic materials can be undertaken. In some cases the variation of laboratory tests with age needs to be considered.

Only the results of the various laboratory tests which have been performed as a part of a preplacement, periodic, or termination examination are included in the following analysis. In those few cases where more than one of these examinations were performed during the July 1, 1960, to June 30, 1961, period, only the results of one examination were used. In all cases the examination used was the one in which the greatest number of laboratory tests had been performed.

Essential data, tables, and figures for each test are presented and followed by a brief summary of the important findings.

COMPLETE BLOOD COUNT

WHITE BLOOD CELL COUNT

The examinations included 3523 men and 553 women. A frequency distribution of the white blood cell counts for each sex appears in Table 1. The differential cell count was not analyzed in detail.

Summary

The mean white blood cell count for men was 7261/mm^3 (σ, ±2.209; 90% range, 3623 to 10,899). The mean white blood cell count for women was 6970/mm^3 (σ, ±2.212; 90% range, 3321 to 10,619). Six hundreths of a percent of the males and 0.3% of the females had white blood cell counts of less than 3000/mm^3, and 3.6% of males and 3.2% of females had counts in excess of 12,000/mm^3. The differential white blood cell count was not analyzed in detail, but the average values for the various cells were the same as reported by Diggs.[12] Occasionally, abnormal morphology of the red and white blood cells was noted, but no new cases of significant blood disease were detected by these two counts alone.

[12] L. W. Diggs, D. Sturm, and A. Bell, *The Morphology of Human Blood*, W. D. Saunders, Philadelphia, 1956.

Table 1. Distribution of White Blood Cell Counts

White Blood Count	Number of Individuals Examined	
	Male	Female
× 100		
0–9	0	0
10–19	0	0
20–29	2	2
30–39	34	9
40–49	331	74
50–59	697	125
60–69	646	112
70–79	551	93
80–89	400	63
90–99	244	29
100–109	139	15
110–119	92	13
120–129	54	8
130–139	25	3
140–149	17	1
150–159	12	4
160–169	3	1
170–179	0	0
180–189	4	0
190–199	1	0
> 199	0	1

Table 2. Hemoglobin Levels

Weight (gm/100 ml)	Number of Individuals Examined	
	Male	Female
< 10	0	7
10	0	5
11	5	29
12	18	80
13	140	210
14	564	155
15	1417	56
16	855	10
17	218	0
18	26	0
> 18	12	0
Total	3256	552

HEMOGLOBIN LEVELS

The examinations included 3256 males and 552 females. Table 2 is a distribution of the hemoglobin values for each sex. A frequency distribution according to age was also tabulated.

Summary

The average hemoglobin for men in the age groups 25 to 29 was 15.37 gm, and the average for age 55 to 59 was 14.98 gm. The averages for women in these same age groups were 13.03 and 13.11 gm. The average hemoglobin for men of all ages was 15.15 gm (σ, ±1.03; 90% range, 13.45 to 16.85 gm). The average hemoglobin for women of all ages was 13.21 (σ, ±1.202; 90% range, 11.22 to 15.19 gm). No significant age effect was detected.

MICROHEMATOCRIT LEVELS

The examinations included 3251 males and 551 females. The number of individuals examined and the average value for 5-year age groups for each sex may be seen in Table 3.

Summary

The microhematocrit level did not vary significantly with age in either sex. The average microhematocrit level for men was 46.51% (σ, ±2.79; 90% range, 42.13 to 51.35%). The average for women was 41.55% (σ, ±3.11; 90% range, 36.43 to 46.68%).

Table 3. Microhematocrit Levels

Age (years)	Male		Female	
	Number of Examinations	Mean Value (%)	Number of Examinations	Mean Value (%)
<20	7	46.71	15	42.53
20–24	182	47.53	100	40.76
25–29	328	46.95	97	40.34
30–34	605	46.54	68	40.63
35–39	682	46.70	95	41.07
40–44	572	46.54	75	41.58
45–49	363	47.03	46	41.52
50–54	255	46.74	28	42.21
55–59	162	46.67	19	42.10
60–64	78	46.51	8	42.87
65–69	16	46.18	0	
70 and up	1	44.00	0	

URINALYSIS

PROTEINURIA

The examinations included 3083 males and 505 females. Tables 4 and 5 list the numbers and percentages of positive results for each age grouping and sex.

Table 4. Frequency and Degree of Proteinuria in Males

Number and percentage for each age group and test results
Shaded area indicates results in males older than 50 years

Age Group	Number of Examinations	Test Results											
		None		Trace		1+		2+		3+		4+	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<20	6	5	83.34	0		1	16.66	0		0		0	
20–24	179	170	94.97	6	3.35	2	1.11	1	0.55	0		0	
25–29	310	286	92.25	15	4.83	7	2.25	1	0.32	1	0.32	0	
30–34	577	551	95.49	22	3.81	3	0.51	1	0.17	0		0	
35–39	639	617	96.55	14	2.19	8	1.25	0		0		0	
40–44	548	531	96.89	15	2.73	2	0.36	0		0		0	
45–49	347	337	97.11	8	2.30	0		2	0.57	0		0	
50–54	236	223	94.49	8	3.38	4	1.69	1	0.42	0		0	
55–59	150	134	89.33	9	6.00	5	3.33	1	0.66	1	0.66	0	
60–64	75	68	90.66	4	5.33	2	2.66	1	1.33	0		0	
65–69	15	14	93.33	0		1	6.66	0		0		0	
>70	1	1	100	0		0		0		0		0	
Total	3083	2937	95.26	101	3.27	35	1.13	8	0.25	2	0.06	0	

Table 5. Frequency and Degree of Proteinuria in Females

Number and percentage for each age group and test results

Age Group	Number of Examinations	Test Results											
		None		Trace		1+		2+		3+		4+	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<20	13	13	100	0		0		0		0		0	
20–24	90	79	87.77	7	7.77	2	2.22	2	2.22	0		0	
25–29	85	79	92.94	5	5.88	0		1	1.17	0		0	
30–34	60	56	93.33	3	5.00	1	1.66	0		0		0	
35–39	89	86	96.62	2	2.24	1	1.12	0		0		0	
40–44	70	68	97.14	1	1.42	1	1.42	0		0		0	
45–49	45	42	95.55	2	4.44	0		0		0		0	
50–54	27	27	100	0		0		0		0		0	
55–59	18	17	94.44	1	5.55	0		0		0		0	
60–64	8	8	100	0		0		0		0		0	
Total	505	476	94.25	21	4.15	5	0.99	3	0.59	0		0	

Summary

The examinations showed that 4.7% of the males and 5.7% of the females tested had protein in their urine. There is a questionable increase in proteinuria in males after age 50. (See shaded area, Table 4.)

GLYCOSURIA

The examinations included 3547 males and 502 females. Table 6 lists the number and percentage of positive results for each sex. This table includes all tests performed, while Table 7 gives the results after the positive tests from known diabetics had been excluded.

Table 6. Frequency and Degree of Glycosuria in Males and Females, Including Diabetics

Number of individuals examined and percentage for each test result (all tests included)

	No Glucose		Trace		1+		2+		3+		4+	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Male	3045	98.8	9	0.29	13	0.42	4	0.12	3	0.09	8	0.25
Female	502	99.4	1	0.19	0		1	0.19	0		1	0.19
Total	3547	98.79	10	0.28	13	0.42	5	0.14	3	0.09	9	0.25

Table 7. Frequency and Degree of Glycosuria in Males and Females, Excluding Positive Results from Known Diabetics

Number of individuals examined and percentage for each test result

	No Glucose		Trace		1+		2+		3+		4+	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Male	3045	99.31	7	0.22	9	0.29	3	0.09	1	0.03	1	0.03
Female	502	100	—	—	—	—	—	—	—	—	—	—
Total	3547	99.41	7	0.19	9	0.25	3	0.08	1	0.02	1	0.02

Summary

The examinations showed that 1.2% of the males and 0.59% of the females had glucose in their urine. After removing the positive results known to be from diabetic employees, 0.69% of males and none of the females had glycosuria.

An age distribution of the positive results was studied, and, even though diabetes is more common in men and women past 50, there did not appear to be any significant increase in glycosuria with advancing age.

MICROSCOPIC EXAMINATION OF URINARY SEDIMENT

White Blood Cells

The examinations included urine specimens from 3086 males and 504 females. The results are summarized in Table 8.

Summary

Eighty-seven percent of the males and 73% of the females had from 0 to 10 WBC per high-power field (examination of the centrifuged specimen). A significantly higher percentage of women (20.0%) than men (2.8%) have pyuria – over 10 WBC. One and three-tenths percent of the male and 2.7% of the female specimens examined showed clumping of the WBC. There did not appear to be any age relationship in either sex.

Table 8. Results of Microscopic Examination of Urinary Sediment – White Blood Cells

Percentage of those having WBC's in urine is shown in parentheses

	Number of Individuals Examined and Percentage of Each Test Result				
	Negative	0 to 10 WBC's	10 to 50 WBC's	Numerous	Loaded
Males	304 (9.8%)	2694 (87.3%)	65 (2.1%)	14 (0.4%)	9 (0.3%)
Females	32 (6.3%)	371 (73.6%)	71 (14.1%)	24 (4.8%)	6 (1.2%)

Red Blood Cells

The examinations included 3085 male and 504 female urine specimens. The results are summarized in Table 9.

Summary

The examinations showed that 2.7% of the men and 4.5% of the women had more than 10 red blood cells per high-power field in the examination of the centrifuged specimen.

Casts

The examinations included 3082 male and 504 female urine specimens. No attempt was made to code an estimate of the number of casts present. Only their presence or absence was recorded. The results are summarized in Table 10.

Summary

Hyalin, granular, or cellular casts were present in the urinary sediment of 2.5% of the men and in 0.19% of the women.

Trichomonas Organisms

Trichomonas organisms were found in 0.0019% of male and 0.0165% of female urine specimens.

Table 9. Results of Microscopic Examination of Urinary Sediment – Red Blood Cells

Percentage of individuals having RBC's in urine is shown in parentheses

	Number of Individuals Examined and Percentage for Each Test Result				
	Negative	0 to 10 RBC's	10 to 50 RBC's	Numerous	Loaded
Males	1028 (33.32%)	1971 (63.88%)	75 (2.43%)	9 (0.29%)	1 (0.06%)
Females	222 (44.04%)	259 (51.38%)	21 (4.16%)	1 (0.19%)	1 (0.19%)

Table 10. Results of Microscopic Examination of Urinary Sediment – Casts

Percentage of individuals having casts in urinary sediment is shown in parentheses

	None	Hyalin	Granular	Cellular
Males	2954 (95.84%)	51 (1.65%)	24 (0.77%)	4 (0.12%)
Females	484 (96.03%)	1 (0.19%)	0	0

Comment

Several factors must be considered in the interpretation of the results of a microscopic examination of a urinary sediment. It has been noted that 20% of women have more than 10 white blood cells per high-power field. This higher percentage is probably due, primarily, to the difficulty in getting an uncontaminated specimen. Although a much larger number of female than male specimens (20% ♀ vs 2.8% ♂) had significant numbers of white blood cells, the percentage in which these cells were clumped was almost the same (2.2% ♀ vs 1.3% ♂). Hoffman[13] and Kolmer[14] believe that clumping of the white blood cells is especially suggestive of a purulent inflammatory process.

The greater frequency of microscopic hematuria (greater than 10 cells per high-power field) in women (4.54%) than in men (2.78%) may also have been due to the difficulty in obtaining uncontaminated specimens. In some cases menstrual bleeding was probably a source of contamination.

It is the general practice of the Health Division physicians to call back individuals who exhibit microscopic hematuria or pyuria in a single specimen in order to get a "clean-catch" specimen. If the findings persist, a more complete examination is performed, and, if no adequate cause can be found, the individual is referred to an outside physician for further studies.

BLOOD PRESSURE DETERMINATIONS

The blood pressures of 2805 males and 405 females were determined. The variation of the systolic and diastolic blood pressures with age is shown in Tables 11 and 12.

Summary

Both the average systolic and diastolic blood pressure of males and females increased slightly with age. The average systolic blood pressure of 2805 males of all ages was 128.16 mm Hg (σ, ±10.78; 90%

[13] W. S. Hoffman, *Biochemistry of Clinical Medicine*, p 237, Year Book Publishers, Chicago, 1954.

[14] J. A. Kolmer, *Clinical Diagnosis by Laboratory Examinations*, 1st ed. (revised), p 85, Appleton-Century, New York, 1944.

Table 11. Age Variation of Blood Pressure – Males

Age	Number	Average Systolic Pressure (mm Hg)	Average Diastolic Pressure (mm Hg)
<40	1456	125.61	80.14
40–44	527	126.62	82.78
45–49	340	130.26	85.91
50–54	244	132.63	85.33
>55	238	139.90	87.35

Table 12. Age Variation of Blood Pressure – Females

Age	Number	Average Systolic Pressure (mm Hg)	Average Diastolic Pressure (mm Hg)
<40	253	115.81	75.29
40–44	69	119.34	78.18
45–49	38	128.92	83.42
50–54	22	124.54	81.81
>55	23	133.26	84.56

range, 103.1 to 153.22 mm Hg), and the average diastolic pressure was 82.35 mm Hg (σ, ±10.78; 90% range, 64.57 to 100.15 mm Hg). No attempt was made to remove those individuals who had been classified as hypertensive either by us or by their family physician, or who were known to be under treatment.

BODY WEIGHT MEASUREMENTS

The individuals, 2664 males and 375 females, were separated into nine body-weight groups. In addition to a normal or, more accurately, an ideal weight group, six overweight and two underweight groups were included. The weight distribution of these groups for each sex is summarized in Table 13 and shown graphically in Figs. 4 and 5.

Table 13. Distribution of Weights of 2664 Males and 375 Females at ORNL

Percentage of Weight Deviation from Ideal Weight	Males		Females	
	Number of Males	Percentage of Males	Number of Females	Percentage of Females
Underweight				
10% or more underweight	109	4.1	58	15.5
1 to 9%	239	8.9	33	8.8
Ideal	154	5.8	63	16.8
Overweight				
1 to 9%	541	20.3	105	27.9
10 to 19%	812	30.5	62	16.5
20 to 29%	500	18.7	26	6.9
30 to 39%	197	7.4	16	4.3
40 to 49%	67	2.5	7	1.9
50% or more overweight	34	1.3	5	1.3

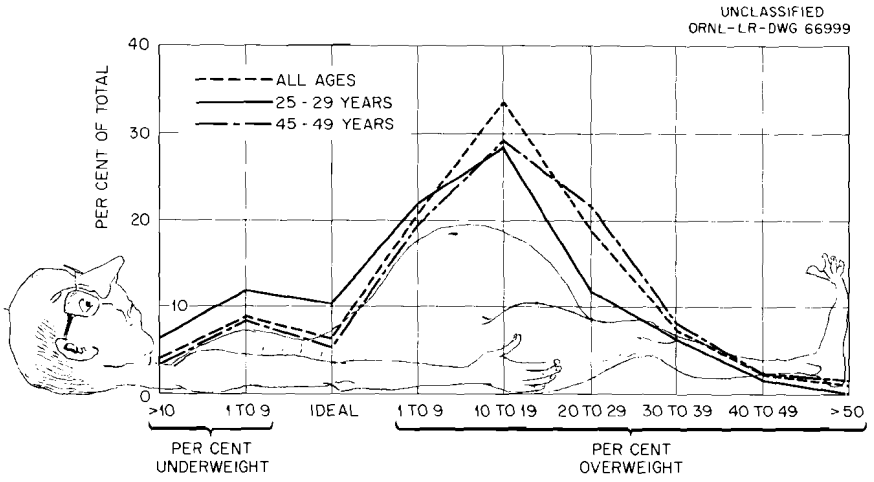

Fig. 4. Weight Distribution of 2864 Male Employees.

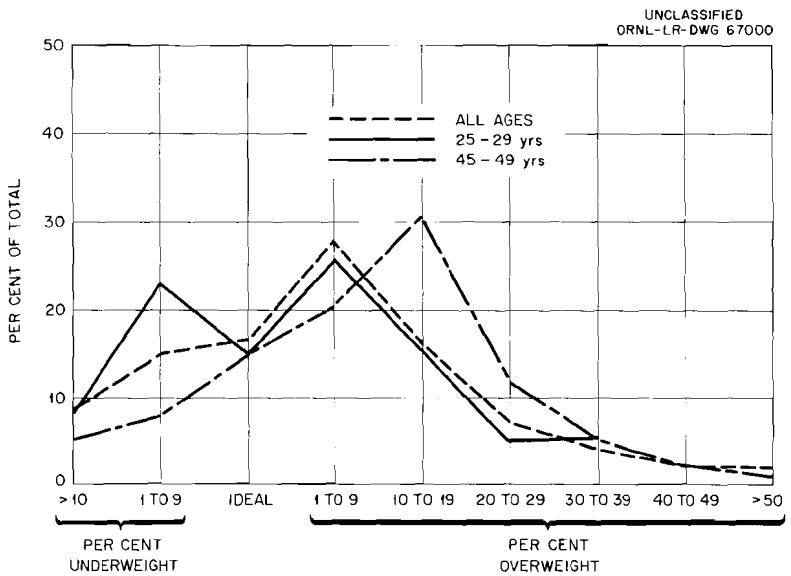

Fig. 5. Weight Distribution of 375 Female Employees.

In the 20-year span between age groups 25 to 29 and 45 to 49 there was an increase in the percentage in the 20 to 29% overweight group, with an approximately equal decline in the ideal and underweight groups. The percentage in the 10 to 19% overweight group remained remarkably constant (28.5% vs 29%) during this time period. The shape of the curve for males did not change appreciably with age, and the outline appropriately suggests a supine fat man, as suggested by our artist.

In contrast, the weight distribution of ORNL women changed markedly with age. Fifteen percent of the women were 10 to 19% overweight at age 25 to 29, but 30.7% were in this group at age 45 to 49. Perhaps the better weight control seen in young ORNL women is related, at least in part, to pride in appear-

ance, attractiveness to males, etc., which subside after age 40. If the stability of their weight distribution can be accepted as an indication, men apparently do not feel or at least do not respond to these pressures as strongly as women.

Summary

The examinations showed that 60.5% of the men and 30.7% of the women are more than 10% above their ideal weight. The basic weight-distribution pattern for men did not change greatly in the 20-year span 25–29 to 45–49. In contrast, twice as many women in the older age group were 10 to 19% overweight as in the 25-to-29 age group.

TUBERCULIN SKIN TEST RESULTS

The examinations included 1651 men and 269 women. The results showed that 4.6% of the men and 4.1% of the women were positive. At the time of the multiphasic examination the nurse asked each individual whether he had been previously positive, and, if so, he was not retested. The interviews included 2287 men and 345 women. In these two groups, 31.3% of the men and 25.21% of the women either had previously had a positive skin test or were positive as a result of our testing in this time period.

RESULTS OF CHEST X-RAY EXAMINATIONS

The examinations included 2990 routine chest x-ray examinations, and 292 (9.76%) had abnormalities which called for comment by the consulting radiologist. He reported only significant changes from previous roentgenograms or persistent abnormalities which he felt should be watched carefully and, in many cases, correlated with the history and physical examination.

RESULTS OF VISION TESTS

There were 2195 vision examinations, made with the Bausch and Lomb Ortho-Rater. Of those examined, 1419 (64.6%) wore glasses either constantly or for reading. The average lengths of time since the last eye examination are listed in Table 14.

Forty-one individuals (1.87%) had essentially monocular vision (less than 20/100, corrected). The right eye was defective in 23 individuals (1.05% of entire group; 56% of defective group), and the left eye was defective in 18 individuals (0.82% of entire group; 43.9% of defective group).

Mildly impaired color vision was found in 158 individuals (7.2%; Ortho-Rater value of 3, with the average normal being 4 to 5), and 102 (4.65%) had severely impaired color perception.

Eleven individuals (0.5%), 9 women and 2 men, reported that they regularly wore contact lenses.

Table 14. Years Since Last Eye Examination

Age	Individuals	Elapsed Years
<20	9	1.66
20–24	45	2.22
25–29	96	2.29
30–34	111	2.51
35–39	146	2.86
40–44	273	2.94
45–49	269	2.11
50–54	231	2.03
55–59	151	2.37
60–64	73	2.31
65–69	14	1.64
70 and up	1	3.00
Total	1419	Av 2.41

Summary

Of the 2195 Laboratory employees given vision tests, 64.6% reported that they wore glasses. They had had their last refraction 2.41 years previous to their test, and the length of time did not seem to be related to their age; 1.86% had essentially monocular vision, with the right eye defective more frequently than the left. Mild impairment of color perception was found in 7.2%, and 4.65% had severe impairment. Eleven individuals (0.5%) reported that they regularly wore contact lenses.

RESULTS OF ELECTROCARDIOGRAPHIC EXAMINATIONS

Summary

Sixteen hundred and seven electrocardiograms were recorded, and 42 (2.6%) were considered sufficiently abnormal that the findings should be correlated with a history and physical examination of the patient.

VDRL

Summary

The State of Tennessee Department of Public Health Laboratory performed 471 VDRL tests for ORNL, and 10 (2.12%) were reported as reactive, with measurable titers. Nine occurred in men. None of the total group had active or latent syphilis which required treatment. Most of the positive reactions were in previously known leutics who had had adequate treatment. Several were apparently false-positive reactors.

Part IV
Special Study of Serum Cholesterol Determinations

Atherosclerosis which becomes manifest as coronary heart disease is the greatest cause of death and disability among Laboratory employees. Since the serum cholesterol level is believed to be useful in detecting individuals who have an increased risk of this disease, it was added to the routine Laboratory testing program in March 1960.

The selection of the method for routine use in our laboratory was influenced by many factors. Since the staff is limited in size, the test had to be relatively simple and quickly performed by a "batch" process. The method of Pearson, Stern, and McGarack,[15] which uses direct colorimetry without saponification, fulfilled these requirements admirably. In this method cholesterol is separated by glacial acetic acid from the globulin protein to which it is bound, and total cholesterol is determined by the Lieberman-Burchard reaction (acetic anhydride plus sulphuric acid). The color which develops is sufficiently stable to enable the technician to add reagents to as many as 20 tubes before measuring the intensity. The cholesterol level is reported in mg/100 cc, commonly referred to as mg %.

ACCURACY AND REPRODUCIBILITY OF RESULTS

Accuracy and reproducibility of results were tested in the following ways:

1. The value of five unknown serums and a control was determined in triplicate by each technician. The results are tabulated in Table 15. The average difference between the mean value for the three tests for each technician was 12.7 mg %.

2. Analyses of 100 consecutive samples were run in duplicate by two technicians. The variation from the lowest to the highest in each pair of tests ranged from 0 to 40 mg %, with an average difference of 13.2 mg % (σ, $\pm$11.7). Confidence limit by the method of Frier and Rausch[16] and Schrock[17] [$1.88 \times \bar{R}(1.28 \times \sigma)$] was $\pm$24.8 mg %. The allowable error based on the mean of the control was $\pm$12.4%.

3. In order to compare our accuracy with other medical laboratories in this area, duplicate samples were sent to three local hospitals and their results compared with ours. Table 16 compares the results.

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[15] S. Pearson, S. Stern, and T. H. McGarack, "A Rapid, Accurate Method for the Determination of Total Cholesterol in Serum," *Anal. Chem.* **25**, 813 (1953).

[16] E. F. Frier and V. L. Rausch, "Quality Control in Clinical Chemistry," *Am. J. Med. Technol.* **24**, 195 (1958).

[17] E. M. Schrock, *Quality Control and Statistical Methods*, Reinhold, New York, 1950.

Table 15. Reproducibility of Analyses

Serum Number and Age of Individual	Test No.	Technician 1 (mg %)	Technician 2 (mg %)	Technician 3 (mg %)	Serum – 1 Week Old (mg %)
Serum 1; age 40	1	190	200	200	195
	2	190	190	200	190
	3	185	200	195	190
Serum 2; age 50	1	270	280	295	270
	2	270	290	290	265
	3	270	290	295	265
Serum 3; age 46	1	300	305	310	290
	2	300	290	305	290
	3	290	315	305	290
Serum 4; age 38	1	350	350	350	340
	2	350	350	355	335
	3	355	370	350	335
Serum 5; age 45	1	265	260	260	260
	2	250	260	250	250
	3	260	250	255	250
Control-serum range, 175 to 195 mg %	1	195	190	195	200
	2	195	190	195	195
	3	200	185	195	200

Table 16. Comparison of Analytical Results from Four Laboratories

Test No.	ORNL (mg %)	Laboratory 1 (mg %)	Laboratory 2 (mg %)	Laboratory 3 (mg %)
1	210	219	195	(239)[a]
2	305	289	(222)	291
Control (180–200 mg %)	185	209	181	(232)

[a]Indicates results of greatest variation.

4. A control serum was analyzed with each batch of tests. If the test result on this serum was not within ±10 mg/100 cc of the midpoint of the control, the entire batch was repeated. The level of the control serum varied with each vial received from the Hyland Laboratories but was always expressed in a 20-mg range, for example, 190–210 mg %.

VARIABILITY OF RESULTS

The relative constancy of the cholesterol level is an important consideration. If there were large variations from day to day or week to week, a single screening test would be of limited value. It has been demonstrated by Boyd[18] that the time after the last meal when the specimen is drawn is not crucial. It is not necessary, therefore, to require the patient to be in a fasting state. Variability during various time intervals was investigated and is summarized below:

1. Variability from day to day: Ten Health Division male employees submitted specimens daily for five days. Day to day variation ranged from 0 to 45 mg %, with an average of 25.5.

2. Variability from week to week: One hundred thirty-one men, all of whom had a screening cholesterol level of 250 mg % or more, returned for three further tests done one week apart. Variation ranged from 0 to 85 mg %, with an average of 28.6.

3. Variability from month to month: Ten men of the Health Division staff varied an average of 43.6 mg % over a period of four months (average of lowest to highest values of four monthly tests). The range over the four-month period was 12 to 95 mg %. The average variability from month to month was 21.1 mg %, with a range of ±65. The average variability of each test with the mean of the four monthly tests was 13.9 mg %, with a range of 3 to 27.5.

4. Variability from year to year: One hundred cholesterol levels done during the first screening series were compared with those in the second series, performed approximately 12 to 16 months later. Variation ranged from 0 to 110 mg %, with an average of 30.45. Fifty-six percent either gained or lost 25 mg % or less. No attempt was made to eliminate those men who had been on a low-saturated-fat diet, had lost weight, or had used medication in an attempt to lower their cholesterol level.

SUMMARY OF ACCURACY, REPRODUCIBILITY, AND VARIABILITY OF TESTS

Although a formal analysis of all variants has not been done, the following conclusions from the evidence presented above seem reasonable.

1. The confidence limit for the analysis of a single unknown specimen, when performed with 18 other unknowns and a known control, is approximately ±25 mg %, an allowable error of 12% of the mean value of the control serum. [The mean difference between 100 pairs of duplicate tests was 13.2 mg % (σ, ±11.7) with a range of 0 to 40. The confidence limit of this group was ±24.8 mg %, or approximately 2 σ.] Usually when analyses on single unknowns are performed, the confidence limit is expressed as 2.66R. This would raise the limit to ±31.12 mg % (approximately 3 σ). To us, however, this seems unreasonably strict for interpretation of a screening type clinical laboratory test. The use of a known control, with the now rigidly enforced policy of rejecting all batches in which the control varies more than ±10 mg % from the known value, would seem to support the use of the more liberal value.

2. The average day to day variability was 25.5 mg %, week to week was 28.6 mg %, and month to month was 13.9 mg %. The average change over the four-month period was ±44.6 mg %.

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[18] E. M. Boyd, "Diurnal Variations in Plasma Liquids," *J. Biol. Chem.* 110, 61 (1935).

When one considers that our test is a screening test, our confidence limit does not compare unfavorably with other laboratories doing much more precise analyses by using other techniques. Benenson[19] reported 8.6%, while Kingsley[20] had 10.0% and Walford[21] 16.8% errors.

For clinical use, a single screening test for serum cholesterol has to be interpreted with caution. The upper limit of normality which is frequently used in this country is 250 mg %. Certainly no action should be based on the result of a single test. It has been the practice in the Health Division to request three additional tests, done a week apart, for all persons having a screening cholesterol level of 250 mg % or more. The average of the four tests is then used. Advice on diet or medication is based primarily on the clinical history (family history of coronary heart disease, history of angina pectoris or previous myocardial infarction, existence of diabetes or chronic renal disease, and heavy cigarette smoking) and the physical examination (obesity, hypertension, abnormal electrocardiogram or cardiomegaly). The cholesterol level alone may be grounds for diet modification if it is consistently above 300 mg %. Recommendations vary with physicians and the interest of the patient.

DISCUSSION OF RESULTS OF THE STUDY

Routine cholesterol determinations were performed on 1113 men age 35 or older. (For schedule, see Part I, p 1.) The average for the group was 234.02 mg % (σ, ±40.81; 90% range, 166.69 to 301.36 mg %). The lowest value recorded was 125 mg % and the highest, 500 mg %. The distribution of the serum cholesterol levels of ORNL men 40 to 50 years old has been added to Rathman's[22] graph of Lewis'[23] data on men in five American cities. This appears as Fig. 6. The ORNL distribution is similar to other locations.

Keys[24] reported an average cholesterol level of 236.56 mg % in 548 men age 30 through 60. At ORNL the average level of 1046 men in this age group was 234.16 mg %.

The relationship of the mean cholesterol level to age may be seen in Fig. 7. There appears to be no significant age effect on the cholesterol level.

The relationship of the mean cholesterol level to body weight is shown in Fig. 8. Individuals with either ideal (normal) or less than ideal body weight have appreciably lower average serum cholesterol levels than those who are overweight. Paradoxically, 18 men at ORNL who were more than 50% overweight had the lowest average serum cholesterol level of the entire group. Whether this is due to some

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[19] A. S. Benenson, H. L. Thompson, and M. R. Klugerman, "Application of Laboratory Controls in Clinical Chemistry," *Am. J. Clin. Pathol.* **25**, 575 (1955).

[20] G. R. Kingsley, "The Control and Precision of Clinical Chemistry Methods," *The Filter* **18**, 1 (1956).

[21] R. L. Walford, M. Sowa, and D. Daley, "Stability of Protein, Enzyme and Non-protein Constituents of Stored Frozen Plasma," *Am. J. Clin. Pathol.* **26**, 376 (1956).

[22] D. M. Rathman, *Unsaturated Fats and Serum Cholesterol*, p 3, Corn Products Refining Company, New York, 1958.

[23] L. A. Lewis *et al.*, "Serum Lipid Levels in Normal Persons. Findings of a Co-operative Study of Lipoproteins and Atherosclerosis," *Circulation* **16**, 227 (1957).

[24] A. Keys *et al.*, "The Concentration of Cholesterol in the Blood Serum of Normal Man and Its Relation to Age," *J. Clin. Invest.* **29**, 1347 (1950).

metabolic disturbance associated with this amount of overweight or just to a chance distribution of low values in a small group cannot be determined without further study. Nevertheless it is an interesting observation.

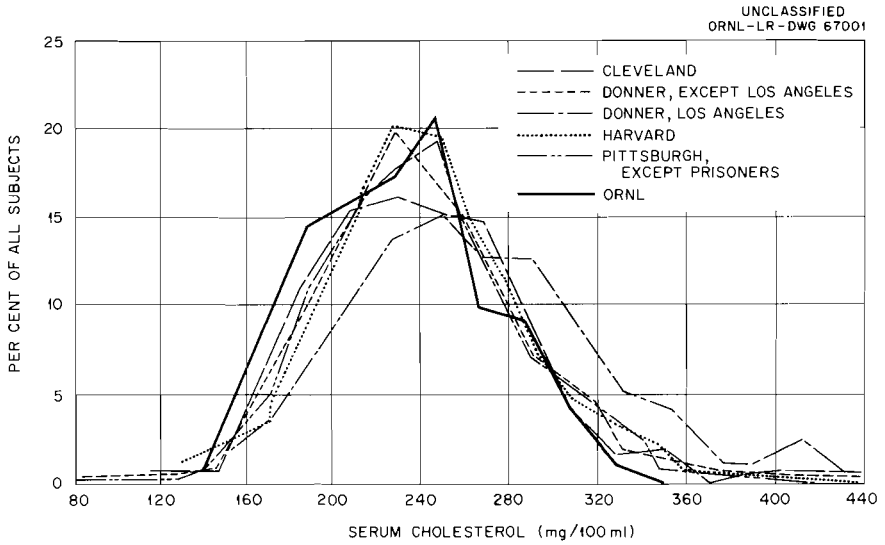

Fig. 6. Serum Cholesterol Levels in 10,500 American Males, 40 to 50 Years of Age. ORNL results compared with results from five cities.

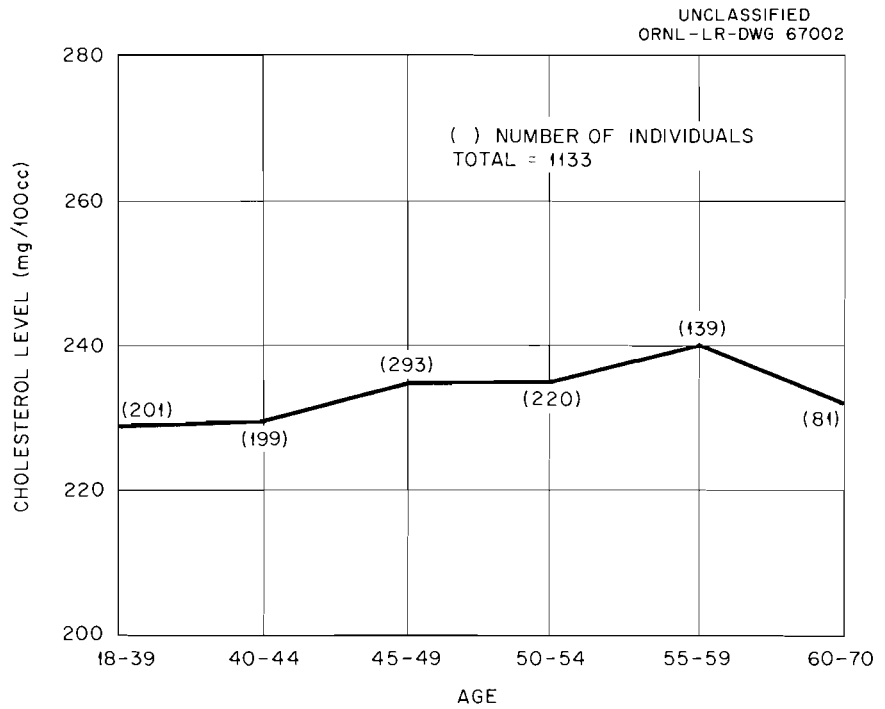

Fig. 7. Relationship of Mean Cholesterol Level to Age.

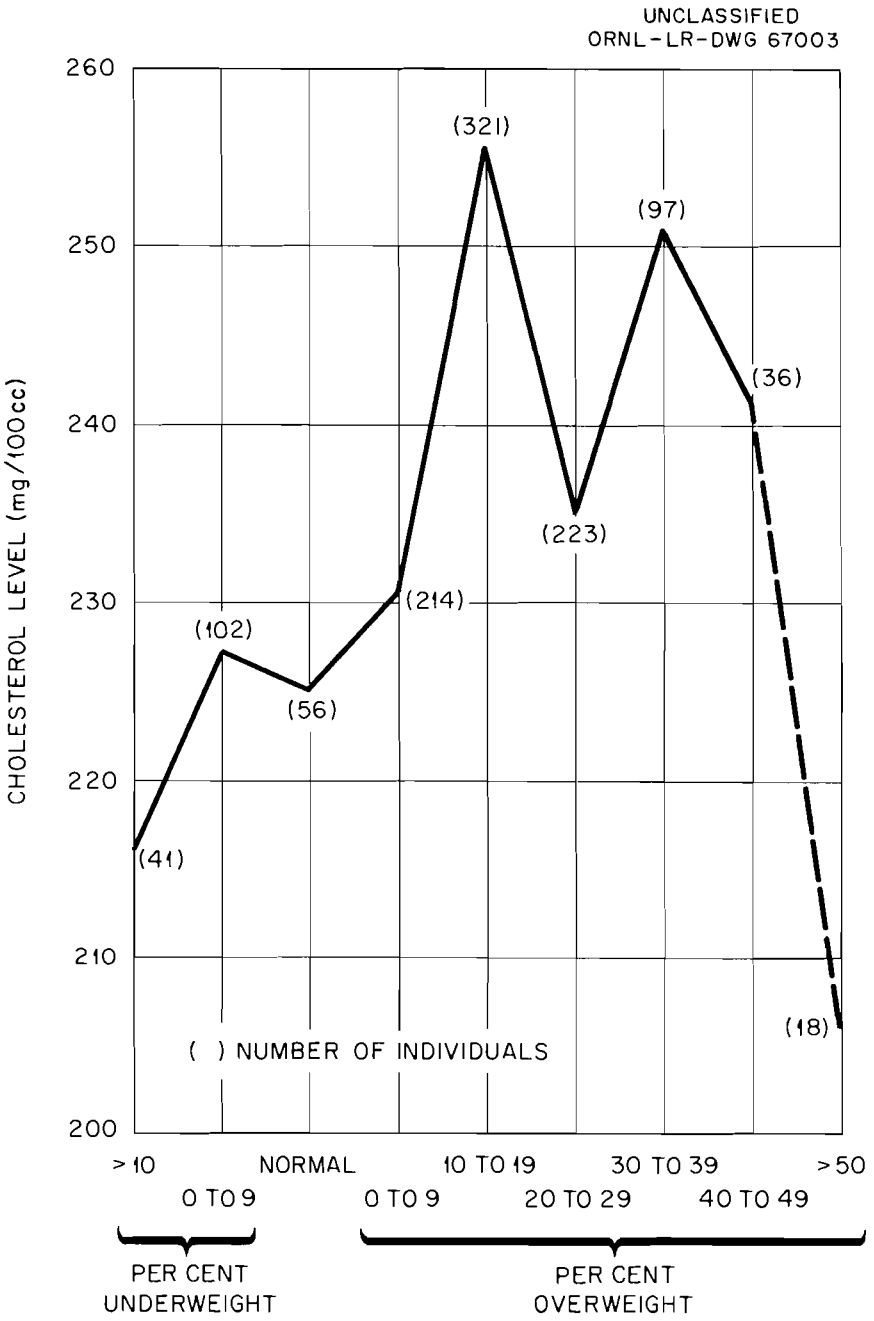

Fig. 8. Relationship of Mean Cholesterol Level to Body Weight.

The relationship of the mean cholesterol level to blood pressure is shown in Fig. 9. Although the number of men with blood pressure over 150 mm Hg systolic and 90 mm Hg diastolic is small, they had higher average cholesterol levels than men with lower blood pressure levels. Pruitt[25] believes that hypertension aggravates, but certainly does not cause, the metabolic disturbance which leads to hypercholesterolemia and atherosclerosis.

Of the ORNL men between the ages of 30 to 64, 6.5% had screening cholesterol levels over 300 mg %, and 33% over 250.

The effect of informing a patient about his elevated screening cholesterol level on his subsequent determinations is of interest. The relationship of the mean screening cholesterol level to the mean subsequent level may be seen in Fig. 10. The period of time between the screening determinations and the three subsequent weekly tests is about two months. Patients are not placed on any specific low-saturated-fat diet or weight-reduction diet at the time they are advised of the elevated screening result and the need for determining a mean cholesterol level. They are aware from national publicity on this subject that hypercholesterolemia is associated with an increased risk of coronary heart disease. The average decline in their cholesterol levels suggests that they might have undertaken some modification of their diet on their own, which caused their cholesterol levels to decline slightly.

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[25] R. D. Pruitt, "Untreated Hypertension," *Southern Med. J.* **54**, 378 (1961).

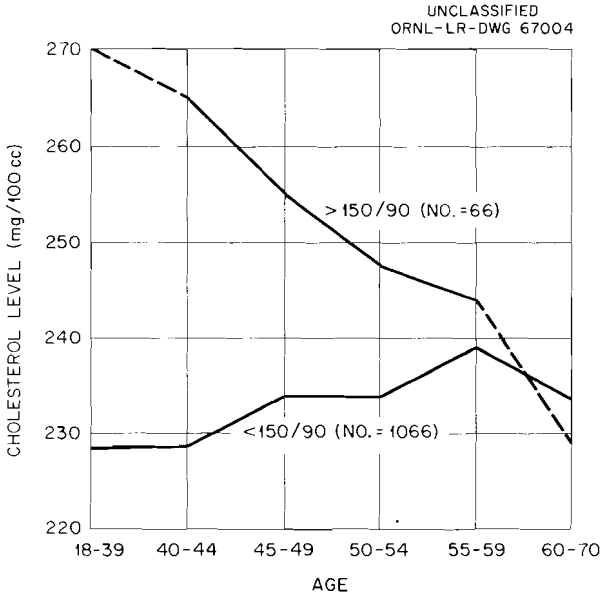

Fig. 9. Relationship of Mean Cholesterol Level to Blood Pressure.

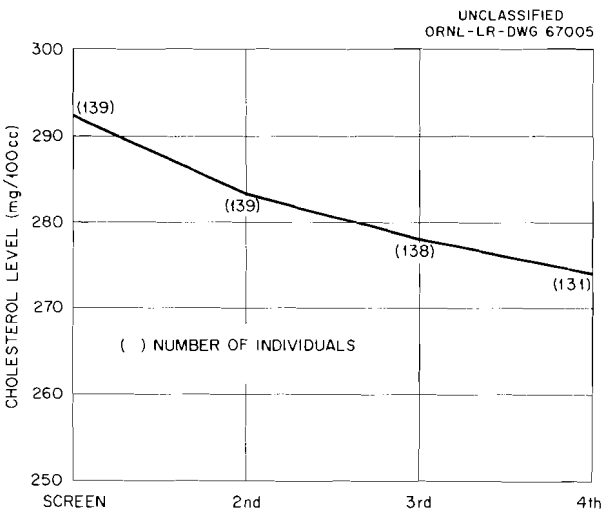

Fig. 10. Relationship of Mean Screen Cholesterol Level to Mean Subsequent Levels.

Part V
Summary of Percentage of Positive Returns of Various Tests

In evaluating the usefulness of various multiphasic laboratory screening tests, one must consider how often significantly positive results are found. In any periodic health evaluation program of working people, one should not expect to find many individuals with newly positive tests. Nevertheless, the reward for performing a particular test must be compared with the effort and expenditure necessary for its performance.

Although each year an average of only one or two cases of active tuberculosis and less than one case of pulmonary malignancy are found at ORNL with the routine chest x ray, these few cases alone justify the expenditure of a considerable sum of money. Although the other findings uncovered during the routine chest x-ray survey cannot be considered life saving, they are of great value in the total evaluation of an employee's health.

Another example of the problems involved in evaluating a particular test is the differential white blood cell count. This test requires approximately 5 min of a technician's time to perform. Only one case of leukemia has been found during the past ten years with this routine test. This same case would have already been suspected by the exceedingly high total white blood cell count. In many laboratories, the differential count is not done unless the total white count is less than 4000 or more than 12,000. However, at ORNL one has to be unusually sensitive to hematological disorders. The earliest possible detection is certainly advisable from a medico-legal standpoint. Of even greater importance is a maximum knowledge of the blood picture of ORNL employees should it ever become necessary to follow changes in individuals who had had heavy whole-body radiation exposure.

The various tests with the criteria and percentage of positives for each test have been tabulated in Table 17. The criteria which are listed are the screening levels which determine which test results are reviewed by a physician. Table 18 is a comparison of ORNL results with other published studies.[24,26–28] Since the composition and age of the populations studied and the screening levels used are so varied, comparison is extremely difficult.

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[26] E. R. Weinerman *et al.*, "Multiphasic Screening of Longshoremen with Organized Medical Follow-up," *Am. J. Public Health* **42**, 1552 (1952).

[27] L. M. Petrie, C. D. Bowdoin, and C. J. McLoughlin, "Voluntary Multiple Health Tests," *J. Am. Med. Assoc.* **148**, 1022 (1952).

[28] B. E. Carroll, A. B. Kurlander, and H. G. Nester, "Multiple Screening Pilot Study," *Public Health Repts. (U.S.)* **69**, 1180 (1954).

Table 17. Criteria and Percentage of Positive Results of Routine Laboratory Tests

Test	Criteria	Male		Female	
		Number	% Positive	Number	% Positive
Urine					
Sugar	Trace or more	3082	1.20	505	0.594
Albumin	Trace or more	3083	4.735	505	5.742
Microscopic					
WBC	10–50 or more	3086	2.85	504	20.038
RBC	10–50 or more	3085	2.78	504	4.56
Other (hyalin and granular casts, cells and trichomonas)	Presence of any number	3082	2.75	504	1.78
Hematology					
Hemoglobin	< 12 gm	3256	0.15	552	7.6
Hematocrit	Male 42–51% Female 36–46%	3251	4.2	551	4.537
White blood count	< 3000 > 12,000	3251	0.06–3.59	551	3.6–3.24
Blood pressure	Systolic pressure > 150	2805	7.8	405	5.10
	Diastolic pressure > 90	2805	18.68	405	9.90
Weight	> 20% aver ideal weight	2664	29.95	375	14.40
Cholesterol[a]	> 250 mg %	79	33.45		
	> 300 mg %	74	6.53		
		Number of Tests		% Positive	
Electrocardiogram[b]	Any abnormality	1607		2.6	
Chest x ray[b]	Judgment of radiologist	2990		9.7	
VDRL (serological test for syphilis)[b]	Positive with or without titer	471		2.3	

[a] Men only; 1133 tested.
[b] No sex separation.

Table 18. A Comparison of ORNL Results with Other Published Results

	Number Studied	Location, Composition of Population, Average Age	Screening Level	% Found
Hemoglobin Results				
Weinerman[a]	3,986	San Francisco; all men (longshoremen); average age, 46.9 years	< 12.3 gm	0.1
Petrie[b]	180,128	Atlanta; mixture, many Negro; average age not given	< 11 gm, male < 10 gm, female	5.4
Carroll[c]	5,711	Indianapolis; 42.9% male; 89% Negro; average age 40.2 years	< 12.5 gm, male < 11 gm, female	16.2
ORNL	3,841	83.1% male; average age 40.6 years; 16.9% female; average age 30.6 years; Negro < 5%	< 12 gm, male and female	0.15 0.6
Urine-Protein Results				
Weinerman[a]	3,988	83.1% male; average age 40.6 years; 16.9% female; average age 30.6 years; Negro < 5%	2+ or more	5
Carroll[c]	5,701	83.1% male; average age 40.6 years; 16.9% female; average age 30.6 years; Negro < 5%	Trace or more	2.2
ORNL	3,588	83.1% male; average age 40.6 years; 16.9% female; average age 30.6 years; Negro < 5%	Trace or more	4.7 male 5.7 female
Chest X-Ray Results				
Carroll[c]	5,701	83.1% male; average age 40.6 years; 16.9% female; average age 30.6 years; Negro < 5%	Judged by radiologist	11.8
ORNL	3,588	83.1% male; average age 40.6 years; 16.9% female; average age 30.6 years; Negro < 5%	Judged by radiologist	9.76
Blood Pressure Results				
Carroll[c]	5,711	83.1% male; average age 40.6 years; 16.9% female; average age 30.6 years; Negro < 5%	Over 150/90	25.7
ORNL	2,805	83.1% male; average age 40.6 years; 16.9% female; average age 30.6 years; Negro < 5%	Systolic > 150 Diastolic > 90	6.4 14.29
Cholesterol Results				
Keys[d]	590	Males, all ages above 35 years	> 300 mg %	1
	474[e]	45 to 70 years	> 320 mg %	1
	432	45 to 60 years	> 300 mg %	5
ORNL	1,133	Males, age 30 through 64	> 250 mg % > 300 mg %	33 6.5

[a]Ref 30. [b]Ref 27. [c]Ref 28. [d]Ref 24. [e]Age 45 through 78.

Summary

Most of the laboratory tests done as a part of a multiphasic screening program yield less than 5% positives. The single most valuable test, in terms of percentage of positive results, was the determination of body weight. The total white blood cell count and the differential count (see p 10) yield the smallest number of significantly positive results. Roberts[29] and others[30-32] found that the single most productive procedure in periodic health evaluations was the physical examination by the physician. An accurate history is of great importance, principally in alerting the physician to areas of probable difficulty. Though the history and the physical examination are complementary, the physician's examination is by far the most important step in a periodic health evaluation. Because the examination is also the most expensive and time consuming, it cannot be done as frequently as some of the laboratory tests.

Unfortunately, because of differences in population sizes and compositions as well as the use of slightly different criteria, only superficial comparisons with other published studies were possible. There were no startling differences.

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[29] J. R. Roberts, "The Values and Limitations of Periodic Health Examinations," *J. Chronic Diseases* 9, 95 (1959).

[30] K. A. Elsom, S. Spoont, and H. P. Potter, "An Appraisal of the Periodic Health Examination," *Ind. Med. and Surg.* 25, 367 (1956).

[31] G. M. Saunders, "Executive Health Programs," *A.M.A. Arch. Indust. Hyg.* 9, 133 (1954).

[32] R. P. McCombs and J. J. Finn, Jr., "Group Health Surveys in Diagnostic Centers," *New Engl. J. Med.* 248, 165 (1953).

Part VI
Industrial Hygiene Activities

The industrial hygiene activities of the clinical laboratory are now performed in the industrial hygiene laboratory in F-47, South Wing, Building 4500. The techniques used, the numbers of examinations performed during July 1960 to June 30, 1961, and, in several cases, the results of the various tests and inspections performed are summarized below.

LEAD DETERMINATIONS

LEAD IN URINE

The method used was an adaptation and modification of the method of Goldman and Jacobs,[33] and 125 individuals were tested.

Spot samples are collected at the first of each month by the leadburners at ORNL. A 100-ml portion of urine is used. All phosphates are removed from the sample by precipitation. These solids are then redissolved, the organics are destroyed, and the lead in the sample is put into a complex, using sulfur dioxide, rendering the lead available for extractions with dithizone. The final color produced is read on a Beckman model B spectrophotometer. The results are reported in milligrams per 1000 cc of sample.

The range of urine lead values, with varying exposures, is listed in Table 19.[34]

[33] Adapted from F. H. Goldman and M. D. Jacobs, *Chemical Methods in Industrial Hygiene*, p 135, Interscience, New York, 1935.

[34] Adapted from A. J. Fleming and C. A. D'Alonzo, *Modern Occupational Medicine*, 2nd ed., p 436, Lea and Febiger, Philadelphia, 1960.

Table 19. Range of Urine Lead Values Under Varying Exposures

	No Industrial Exposure	"Safe" Industrial Exposure	"Hazardous" Industrial Exposure
Concentration range of lead in individual samples, mg/liter	0.01 to 0.06	0.01 to 0.15	0.08 to >0.4
Mean concentration of lead, mg/liter	0.03	0.08	>0.2

LEAD IN BLOOD

The method mentioned above was used, and 62 individuals were tested.

A blood sample is collected from the leadburners at ORNL once every three months. The clotted blood sample is put into complete solution with nitric acid. All organics are then destroyed and the lead is then put into a complex with sulfur dioxide. The lead is then available for extraction with dithizone. The final color produced is read on a Beckman model B spectrophotometer. The results are reported in milligrams per 100 gm of blood.

The range of lead values in blood, under varying exposures, appear in Table 20.[34]

Table 20. Range of Lead Concentration in Blood, According to Various Exposures

	No Industrial Exposure	"Safe" Industrial Exposure	"Hazardous" Industrial Exposure
Concentration range of lead in individual samples, mg of Pb per 100 gm	0.01 to 0.05	0.01 to 0.07	0.07 to 0.2
Mean value of concentration, mg of Pb per 100 gm	0.03	0.06	0.09

CAFETERIA INSPECTIONS

Thirteen inspections were made. The cafeteria is inspected twice each month. Once every three months a bacterial culture examination is made.

The procedure for inspection used is that set forth by the Federal Security Agency of the United States Public Health Service, Washington, D.C. Form 8967 Federal Security Agency, Public Health Service (May 1943) is the standard form on which inspection reports are made.

BACTERIOLOGICAL EXAMINATIONS

WATER ANALYSES

A total of 510 examinations were made, distributed as follows.

ORNL	160
Y-12	335
Private individuals	15

The method was the Millipore filter method used in water bacteriology.

The samples are collected weekly from various locations within the plants. ORNL samples are collected by the Operations Division under M. A. Bugg, and Y-12 samples are collected by the Industrial Hygiene Division under J. F. Moorehead. The samples are collected according to a standard method.[35]

The "coliform group" organisms are filtered out of a known quantity of sample. The filter disk is placed on a hydrated pad containing m-Endo medium and incubated for at least 24 hr. It is read by counting all the colonies showing a green metallic sheen on its surface.

Coliform concentrations in excess of 1 colony per 100 ml of sample indicate the need for regulatory or corrective measures. Positive cultures were found in 4.9% of the samples, distributed as follows:

ORNL	3.8%
Y-12	2.1%
Private individuals	80.7%

CHEMICAL DETERMINATIONS FOR FLUORIDE

Four determinations were made according to the Scott-Sanchis method.

Samples are collected weekly from the main reservoir of ORNL according to a standard method.[35]

The simple test procedure is based on the addition of a complex reagent to 100 ml of sample. The color produced is then compared to a permanent standard with a range of 0.0 to 1.6 ppm of fluoride.

The U.S. Public Health Service recommends that the presence of fluoride in excess of 1.5 mg/liter should constitute grounds for rejection of the water supply.

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[35] *Standard Methods for the Examination of Water, Sewage and Industrial Wastes*, 10th ed., American Public Health Association, Inc., New York, 1960.

Part VII
Tabulation of Tests Performed – July 1, 1960, to June 30, 1961

The clinical laboratory and the x-ray department perform many nonroutine tests. Most of these are done at the request of the staff physicians to assist them in evaluating either occupational or nonoccupational illnesses or injuries. Each year a number of laboratory procedures are also done at the request of the private physician. These requests are honored because it often prevents loss of time from work for the employee. This is especially true of tests which must be repeated many times, for example, prothrombin time for employees with coronary heart disease who are taking anticoagulant medication.

The laboratory is prepared to perform a number of other tests not listed below, but these were not requested during this period and are not included. Routine tests are listed first and are followed by tests requested by physicians.

Record of Tests Made

Number of Tests		Name of Test	Method
3808	Routine	Hemoglobin	See Part II
1380	Special		
5188	Total		
3802	Routine	Microhematocrit	See Part II
1453	Special		
5255	Total		
3806	Routine	White blood cell count	See Part II
1430	Special		
5236	Total		
4792[a]		Examination of stained blood smear	See Part II
3588	Routine	Urinalysis (complete)	See Part II
1871	Special		
5459	Total		

Record of Tests Made (continued)

Number of Tests		Name of Test	Method
3210	Routine	Blood pressure	See Part II
3039	Routine	Height and weight	See Part II
2454	Routine	Tuberculin skin test	See Part II
4025	Routine	Chest x ray	See Part II
267	Special		
4292	Total		
2195	Routine	Vision	See Part II
991	Special		
3186	Total		
876[a]	Total	Visual field	See Part II
2664[a]	Total	Hearing (audiogram)	See Part II
1607	Routine	Electrocardiogram	See Part II
374	Special		
1981	Total		
1139	Routine	Cholesterol	See Parts II and III
638[b]	Special		
1777	Total		
471	Routine	Serological test for syphilis (VDRL)	See Part II
678[c]	Speciol		
1149	Total		
536	Total	Blood type and Rh factor	See Part II
208		Sedimentation rate	Sedimentation rates are reported at the end of 60 min, uncorrected; a hematocrit is reported with each sedimentation rate (Wintrobe, *Clinical Hematology*, ed. 4, p 318)
136		Blood glucose	Read on Coleman Jr. spectrophotometer [Folin-Wu, *J. Biol. Chem.* **38**, 106 (1919)]
19		Glucose tolerance	A single dose of 100 gm of glucose is used [Janney and Isaacson, *JAMA* **70**, 1131–34 (Apr. 20, 1918)]
23		True glucose	This method is not in general use in the laboratory; the number of tests done during July 1960 to June 1961 represent glucose values under investigation and comparison to the Folin-Wu method. (Beckman/Spinco ultramicro adaptation, method of Kiston and Teller)

[a] Routine and special requests not separated.

[b] Includes repeats and mean cholesterol determinations after routine screening.

[c] A serological test for syphilis is performed on all visitors who will be at ORNL for more than 3 weeks.

Record of Tests Made (continued)

Number of Tests	Name of Test	Method
20	Electronic component color-vision test	Test devised by R. G. Affel of the Instrument Division of ORNL to check the ability of an employee to read the color coding of resistors and wires
7	Nonprotein nitrogen	With the stabilization of the final Nessler's color by the method of Gentzkow and Mason; the percent transmittance of the developed color of the test is read on the Coleman Jr. spectrophotometer [Gentzkow and Mason, *J. Biol. Chem.* **143**, 531 (1942)]
27	C-reactive protein	The method and C-R-P-A test kit of Schieffelin & Co. is used; this method is based on the procedure described by Abernathy and Avery, *J. Exptl. Med.* 73, 173 (1941)
97	Prothrombin time	The reagents and method of the Warner-Chilcott Co., Morris Plains, N.J. are used
10	Stool for occult blood	Guaiac-Tabs, made by Cambridge Chemical Products, Inc., Dearborn, Mich., for semiquantitative estimation of blood present are used
1	Red blood count	The count is made using the standard (1:200) dilution pipette and the Neubauer counting chamber and is reported as the number of red blood cells per mm^3 of whole blood
86	Research serums prepared	The serums were collected for a research study on rheumatoid arthritis performed under the direction of Dr. Sidney Cobb, University of Pittsburgh; our laboratory was involved in collection of the blood sample, separation of the serum, labeling and freezing the serum specimens for shipping
2	Cephalin flacculation	Reagents of Chappel Laboratories, West Chester, Pa., are used; method – Hanger Flocculation test [Hanger, *Trans. A. A. Assoc.* **133**, 909 (1947)]
7	Hetrophil antibody test	Sheep cells, obtained from Certified Blood Donor Service, Inc., Jamica, N.Y. are used; method of Paul and Bunnel, as described by Wintrobe in *Clinical Hematology*, ed. 4, p 114
1	Test for achlorhydria	Diagnex Blue test procedure and reagents of E. R. Squibb & Sons, New York, are used; method – tubeless gastric analysis
30	Uric acid	Method, modification by Archibald (Coleman Clinical Methods for Coleman Jr. spectrophotometer) of the Kern & Stransky procedure, *Biochem. Z.* **290**, 419 (1937)
1	Capillary fragility test	Rumpel-Leede test as described by Wintrobe in *Clinical Hematology*, ed. 4, p 288

Record of Tests Made (continued)

Number of Tests	Name of Test	Method
3	Monilia smear	Microscopic examination of a wet preparation for yeast-like structures
4	Stool for ova and parasites	The specimen is concentrated using the formalin-ether sedimentation method of Ritchie; identification is made by microscopic examination of the sediment; Ritchie, "An Ether Sedimentation Technique for Routine Stool Examination," *Bull. U.S. Army Med. Dept.* 8, 326 (1948)
19	Bacteriological smears	Routine staining methods are used (usually a Gram's stain) and identification is made by microscopic examination
4	L. E. preparations	The method of Magath and Winkle for demonstrating lupus erthematosis cells is used [Magath and Winkle, *Am. J. Clin. Path.* 22, 586 (June 1952)], as described by Diggs, Strum, and Bell in *Morphology of Human Blood Cells*, p 170
3	Icterus index	The method described by Wintrobe is used as a screening procedure (Wintrobe, *Clinical Hematology*, ed. 4, p 163) Visual comparison of the color of the plasma is made with that of a series of permanent standards; the results are reported in Meulengracht units
10	Bromsuphalein test	The dosage of 5 mg of bromsulphalein per kilogram of body weight as adopted by the Mayo Clinic is used; bromsulphalein dye ampules are obtained from Hynson, Westcott & Dunning, Inc., Baltimore; retention of the dye is measured photometrically after a 45-min interval; (Magath, "The Takata-Ara Test of Liver Function," *Am. J. Digestive Diseases & Nutrition* 2, 713–16); photometric method: Thorngate, *Clinical Laboratory Procedures*, ed. 2, 1953
1	PBI	Serum for protein-bound iodine determination is sent to the Bowman Gray School of Medicine, Winston-Salem, N.C.
5	Platelet count	Direct counting method used; see Brecher, Schneiderman, and Cronkite, "The Reproducibility and Constancy of the Platelet Count," *Am. J. Clin. Path.* 23, 15 (1953)
2	Spermatozoa count	Total amount of the seminal fluid estimated; percent motility and a morphological examination of the spermatozoa is made by a microscopic study of a wet preparation of the specimen; method as given in Kolmer, Spaulding, and Robinson, *Approved Laboratory Technic*, ed. 5, p 285

Record of Test Made (continued)

Number of Tests	Name of Test	Method
		Reference used for abnormal morphology, Hotchkiss, *Etiology and Diagnosis in the Treatment of Infertility in Men*, 1952
7	Nasal smear for eosinophils	Smear is stained with Wright's stain, and a microscopic examination is made to estimate the percent of eosinophils (Bray, *Clinical Laboratory Methods*, ed. 5, p 587)
1	Bleeding time	Duke method as described by Bray, *Clinical Laboratory Methods*, ed. 5, p 185
40	Coproporphyrin	Method used is that described by Hammond, Taylor, and Pipkin, "Coproporphyrin Determination and Urinary Lead Relationship," *Indust. Hyg. Quart.*, pp 164–65 (September 1952)
6	Urine for bile	Ictotest reagent tablets of Ames Co., Inc., Elkhart, Indiana, are used for a semiquantative estimation of urine bilirubin
11	Reticulocyte count	Saline solution of cresyl blue dye is mixed with an equal quantity of blood; after 2 min a blood film is made of the mixture; a microscopic examination of 1000 red cells is made and an estimation of the percent reticulocytes recorded (Wintrobe, *Clinical Hematology*, ed. 5, p 87)
5	Bleeding time	Capillary-tube method (McGowan's modification) as described by Bray in *Clinical Laboratory Methods*, ed. 5, p 183
1	Blood indices	The values for (1) gm % hemoglobin, (2) red blood cells/mm^3 whole blood, and (3) vol % packed cells (Wintrobe macrohematocrit) are determined in duplicate; the Best's Anemia Classification [Best, *J. Lab. Clin. Med.* (March 1949)] is used to calculate the mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration; a microscopic examination of a blood smear (Wright's stain) is made and morphology of the red blood cells reported
5	Basal metabolic rate	A respiration graph showing minutes to consume 1 liter of oxygen is made, using the Jones Motor-Basal metabolism unit (Jones Metabolism Equipment Co., Chicago, Ill.); age, sex, height, weight, and minutes to consume 1 liter of oxygen is plotted with the Jones automatic basal metabolism calculator to determine percent metabolic rate; temperature, pulse rate, and blood pressure are recorded with each test

Record of Tests Made (continued)

Number of Tests	Name of Test	Method
1	Serum bilirubin	Procedure used is that of Mallory and Evelyn, *J. Biol. Chem.* 119, 491 (1937) and Ducci and Watson, *J. Lab. Clin. Med.* 30, 293 (1945), as described in the "Manual of Clinical Methods for the Coleman Jr. spectrophotometer"
8	Febrile agglutinations	Diagnostic febrile antigens obtained from Hyland Laboratories, Los Angeles, Calif., are used
48	Exercise electrocardiogram	Two methods are used, as requested by physician: (1) Master's two-step [Master, "Electrocardiogram and Two-Step Exercise: Test of Cordiac Function and Coronary Insufficiency," *J. Am. Med. Soc.* 207, 435 (April 1944)]; (2) Double Standard Two-Step Exercise Test of Robb, Marks, and Mattingly, "Value of Double Stondard Two-Step Exercise Test in Detection of Coronary Disease," *Assoc. Life Ins. Med. Directors of America*, 1957
26	Bacteriological cultures	All types of material for bacteriological study are cultured on specific medias, and identification of the organism is made according to the cultural characteristics as described in Bergey's *Manual*
19	Bocteriological sensitivity study	Standard procedure, University of Tennessee Memorial Research Center and Hospital, Knoxville, Tenn.; the antibiotics and the concentrations thereof are set up according to the above procedure; 16 antibiotics are used, and the study can be determined on a growth culture of one or more organisms; readings are reported as sensitive, slightly sensitive, and resistant; the disks are supplied by the Baltimore Biological Laboratory, Baltimore 18, Md.

STAFF OF THE HEALTH DIVISION CLINICAL LABORATORY

Bobby S. Joslin, Evelyn M. Hall, Mary Jo Pryor, and E. M. Barber.

X-ray technician – T. L. Tuck, Jr.

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