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Chapter I

Introduction

The usefulness of lead and its compounds in many fields of human activity has given them a unique place among the materials and products of early arts and crafts, and of modern industry. Thus ample opportunity has been afforded for the demonstration of their poisonous properties. The insidiousness in the development of lead poisoning, the apparent capriciousness of its occurrence, and the variety of its clinical forms, have joined to arouse the curiosity of investigators, and to stimulate their efforts in the interpretation and the mitigation of this occupational menace. And yet a degree of vagueness as to the physiological activities of lead compounds maintains a lively interest in the subject, this being heightened by the fact that whereas the means of prevention of poisoning have steadily improved, new uses for lead-bearing materials have developed at a more rapid pace, involving an increasing number of occupations and persons in the hazards of lead exposure. Indeed, the number of generally distributed commodities which contain ~~some quantity of~~ lead has become so great that some degree of lead exposure has been carried into the everyday life of all persons.

The investigations which are the subject of this volume derive their importance chiefly from the fact that

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they provide ~~constitute~~ ~~the only~~ a source of information as to the magnitude of the lead exposure intrinsic in modern life. They began in 1924 when it became apparent that the previously limited distribution of gasoline containing tetraethyl lead might develop into a commercial activity of very wide proportions. The experience of those who had developed and dispensed this fuel up to that time indicated that there was no acute or immediate danger, but the possibility existed that prolonged exposure to small amounts of lead under the [redacted] conditions arising from the distribution and use of the commodity, might cause a significant accumulation of lead in the tissues of many persons in the industry and in the community at large. It is not my purpose, here, to discuss all the work which has been carried out in this laboratory or elsewhere, in the study of this hygienic problem. Much of the information bearing on the subject is readily available to those who are interested. However, one phase of our work has resulted in the discovery of facts which are of such significance as to justify their detailed presentation both in relation to the original question at issue, and to the larger problem into which it has come to be merged.

Periodic investigations have been made to determine the extent of the lead exposure associated with leaded gasoline, by the careful study of selected groups of persons who have experienced the longest and most severe exposure to the conditions established by its use. Kehoe and Edgar[1] carried out the first observations of this type in 1924-25. Late in 1925, J. P. Leake[2] and his associates in the United States

Public Health Service, following a program outlined by a committee of experts appointed by the Surgeon General, investigated the matter further and extended the number and type of subjects observed. This laboratory ~~[illegible]~~ made three further studies, in the winter months of 1926-27[3], 1927-28[4], and 1929-30 respectively, the first two having been made the subject of detailed reports to the United States Public Health Service, and to the officials of the industry involved. None of the data have been put into such form as to be generally available.

The primary purpose of these investigations could not be served ~~merely~~ by attempting to detect evidences of lead intoxication in exposed persons. Rather, it seemed imperative to anticipate ~~any~~ such developments by determining whether the lead exposure was sufficient to bring about lead accummulation, and ultimately to ~~which might eventually~~ induce lead intoxication. Such a purpose required not only accurate methods for making observations, but also sound physiological bases for their interpretation.

As a preliminary step in the estimation of human lead absorption, satisfactory means for the measurement of minute amounts of lead in biological material had to be determined upon. This accomplished, the next step was to find some measurable factor which bore a constant relationship. It seemed probable that either the rate of lead excretion, or the lead concentration in the blood might be such a factor.

~~is a constant relationship between the rate of absorption and the rate of excretion, or between the amou d the rate of excretion. [illegible] analytical observations on the blood might indicate~~ the quantity of absorbed ~~lead~~. Moreover, ~~Or, it might be that~~ some other quality ~~physiological factor susceptible of clinical observation~~ might ~~could~~ be found to vary with the magnitude of lead absorption, as for example, the microscopic changes in the blood. Lacking adequate information on these points we were ~~it became~~

~~were~~ forced ~~necessary~~ to combine ~~[illegible]~~ clinical and analytical ~~observations with the collection of analytical and other data~~,

methods in the study of [illegible]ied groups of subjects with known and unknown exposure t[illegible]d compounds. In short, nothing less than a comprehensive examination of ~~[illegible]~~ the physiological behavior ~~[illegible]~~ of lead compounds ~~[illegible]~~ came to be the subject of investigation.

The several years ~~that~~ have been devoted to such efforts, have demonstrated ~~conclusively~~ that the normal individual in the United States, with ~~experiencing~~ no industrial exposure to lead compounds, ~~is~~ excreted ~~s~~ measurable quantities of lead in both the faeces and urine. The first observations indicative of this ~~situation~~ were reported by Kehoe, Edgar, Thamann and Sanders[5]. The facts as to faecal excretion were verified by Leake[2] and his associates shortly afterward. They have been established ~~on an entirely trustworthy basis~~ by the extension of our observations to several groups of carefully selected normal subjects. Francis[6] and his associates, as well as Millet[7], have recognized ~~established~~ the existence of a similar condition ~~situation~~ in England. ~~Various groups of workers,~~ Badham and Taylor[8], Cooksey and Walton[9], and Tannahill[10], have obtained like results in Australia, while Fretwurst and Hertz[11] and Weyrauch and Hitzner[12] have reported similar findings in Germany. We[13], as well as others[14], have shown, further, that the rate of lead excretion in faeces and urine varies with the magnitude of lead exposure to such a degree as to differentiate groups of

de [illegible] reported negative findings re normal lead in French subjects (see [illegible]).

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workers in the lead trades from each other and from the non-industrialized population. These facts have led to the further investigation of the conditions of exposure to lead both in the lead trades and in the community at large. Without minimizing ~~detracting in any way from~~ the importance of the original problem, the study of the lead absorption of the general population has claimed an increasing amount of attention. This has become the more necessary since those persons who have had the most severe and prolonged exposure to the hazards of leaded gasoline have failed frequently ~~fail~~ ~~[illegible]~~ to differentiate themselves from unexposed persons, on the basis of their lead excretion or any other factor. Whether this is due to the limitations of the methods of observation or whether it is the result of an ~~[illegible]~~ insignificant magnitude of the leaded-gasoline factor in the total picture, can be determined satisfactorily only by the ~~recognition and~~ appraisals of the several sources which contribute to the absorption of lead by the average normal man. By the same process one may hope to obtain some evidence as to whether such lead absorption is now or is likely to become significant in relation to the public health.

Thus a number of problems have presented themselves, as the direct outgrowth of what may appear to have been a simple experimental study. Certain specific questions may be formulated as matters for examination ~~interest~~, as follows:

1. What are the sources of the lead absorbed by the average normal man in the modern American community?

2. Does normal lead absorption have any hygienic significance.

Is lead absorption

3. ~~Are these~~ the result of modern industry and commerce, or ~~are they~~ is it a ~~inextricably bound up with the~~ condition~~s~~ of life on a lead-bearing planet, or are both factors active?

4. Are there evidences of an increase in lead exposure as a consequence of the distribution of leaded gasoline, or of any other commodity or factor of modern origin?

5. What rate or amount of lead absorption is associated with the occurrence of lead poisoning?

The ~~methods which have been employed, and the~~ results which have been obtained in answer to these questions, are dealt with in the chapters which follow. The order of presentation of the material is not that of experimental progression. It is rather that which has been determined by the sequential relationship of the results. Since the validity of conclusions depends upon the accuracy and adequacy of specific experimental methods, these are described in detail in the appendix.

Bibliography

1/ Kehoe, Robert A., and Edgar, Graham: A Study of the Hazards Associated with the Sale and Distribution of Ethyl Gasoline. Printed report to United States Public Health Service and Ethyl Gasoline Corporation, June 1925.

2/ Leake, J. P. and others: The Use of Tetraethyl Lead Gasoline in its Relation to Public Health. U.S. Public Health Bulletin No. 163, 1926.

3/ Kehoe, Robert A. and others: A Study of the Health Hazards Associated with the Distribution and Use of Ethyl Gasoline. Printed Report to United States Public Health Service and Ethyl Gasoline Corporation, May 1927.

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4
Kehoe, Robert A. and others: A Study of the Health Hazards Associated with the Distribution and Use of Ethyl Gasoline. Printed report to United States Public Health Service and Ethyl Gasoline Corporation, April 1928.

5
Kehoe, Robert A.; Edgar, Graham; Thamann, Frederick; and Sanders, Lester: The Excretion of Lead by Normal Persons. J. Am. Med. Assn., 87: 2081, (1926)

6
checked
Francis, A. G., Harvey, C. O., and Buchan, J. L.: The Determination of Small Quantities of Lead, with Special Reference to Urine and Biological Materials. Analyst, 54: 725, December 1929.

7
checked
Millet, Horace: The Excretion of Lead in Urine J. Biol. Chem., 83:265, (1929)

8
Badham, Charles, and Taylor, H. B.: Studies in Industrial Hygiene, No. 7, Lead Poisoning, Report of Director General of Public Health, New South Wales, for year 1925, Sydney, (1927).

9
Cooksey, T., and Walton, S. G.: Electrolytic Determination of Lead in Urine, Analyst, February 1929. (54: 97)

10
Tannahill, R. W.: The Excretion of Lead by Mine Workers at Broken Hill. Med. Jour. Australia 1: 201, (1929).

11
checked
Fretwurst, Fritz, and Hertz, Artur: Quantitative Determination of Lead in Faeces and Urine and Its Significance in Making a Diagnosis of Lead Poisoning, Arch. f. Hyg., 104: 215, (1930).

12 - Weyrauch F, and Lutzner, St.: Investigation of the excretion of lead by the kidney, and its response to certain forms of diet and medication in human beings. Part II Concerning the so-called normal lead in the urine, Arch. f. Gewerbehyg. 3: 15, 1932

13
Kehoe, Robert A., and Thamann, Frederick: The Excretion of Lead, J. Am. Med. Assn. 92: 1418, (1929).

14
Leake, J. P. and others: Loc. cit.
Badham, Charles, and Taylor, H. B.: Loc. Cit.
Taylor, H. B.: The Determination of Minute Quantities of Metals in Biological Material Part 1; J. Proc. Roy. Soc. New South Wales, 61: 315 (1927).
Francis, A. G., Final Report of Dept. [illegible] Com. on Ethyl Petrol, Ministry of Health, Great Britain. (1930)
Tannahill, R. W. Loc. cit.

Chapter IV

The Absorption and Excretion of Lead in Primitive Life

No information was available as to the natural presence of lead in human tissues. Nor was it possible to determine whether or not some quantity of lead is to be regarded as a normal constituent of the animal organism if observations were confined to industrialized parts of the earth. On the other hand, it ~~would~~ seemed that there should be places that have escaped the commercial developments of present day civilization, and in which the opportunities for lead absorption ~~are~~ were of the same type as those of primitive men. A cursory examination of localities which offered some chance for the existence of such conditions, led to the consideration of Mexico as a field for experimentation. Certain requirements were set up as the basis for the selection of specific communities, as follows:

(1) The conditions of life must be such as to exclude the possibility of occupational exposure to lead compounds at any time; (2) There must be complete freedom from such opportunity for lead absorption as would come from the use of lead paints on the outside or inside of dwellings, or on objects of general utility, as well as the use of canned goods, metal containers and cooking utensils, piped water supplies, and machinery of any kind; ~~was to be regarded as adequate basis for the exclusion of any group of subjects;~~

(3) Proximity to cities, or easy transportation facilities to and from highly organized communities constituted a further objection;

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(4) ~~M~~mining and smelting activities, with special reference to lead-containing ores, must not be carried on within such a distance as might provide opportunity for contamination of vegetation, surface soil or water supply; (5) the

(5) ~~The~~ employment of firearms, and the inclusion in the diet of game obtained through the use of firearms to any considerable extent, was ~~accepted as~~ reason for exclusion; and (6), there

(6) ~~There~~ must be a considerable number of people available for study, and willing to provide samples of blood and excreta, as well as articles of food and objects of general use.

nothing else

Persons ~~who are~~ familiar with ~~the~~ Mexico ~~scene~~ will recognize how easily many parts of that amazing country meet these requirements. ~~but to our minds the conditions were so exacting as to arouse considerable doubt as to their complete fulfillment.~~ Nevertheless, plans were made to carry out experimental studies, and in July of 1931 the work began. Through the generous assistance of colleagues in the Department of Public Health of Mexico, it was possible to establish the probable suitability of several small communities within comparatively short distances of Mexico City, and after ~~detailed~~ examin~~ation of~~ several such villages and (after) establishing mutually friendly relationships with the native Mexicans, our doubts were ~~largely~~ dispelled. ~~and~~ Experimental work was undertaken in two pueblos. Since any conclusions as to the natural occurrence of lead in human beings must depend wholly upon the absence of artificial opportunities for lead exposure, a description of these two villages and of life within them is necessary.

Pueblo de Cachi, ~~is~~ a small village of about one hundred families, is situated on the Mexican plateau, about five kilometers from the village of Ixtlahuaca, and thirty-one kilometers northwest of Toluca, in the State of Mexico. At first sight, the vast expanse of level plain in the region appeared as though uninhabited. There were no towns with obvious ~~highways~~ leading to them, or with the smoke of factories hanging over them. ~~In fact~~ the only evidence of human existence in the immediate vicinity was furnished by occasional flocks of cattle, turkeys and chickens foraging under the care of children.

MP The adobe houses ~~of Cachi~~ were ~~completely obscured by corn almost ready for the harvest, so that only by standing on a hummock could the tile or clapboard roofs be seen~~ scattered at irregular intervals in the midst of ~~the~~ a ~~communal~~ field of ~~grain~~ corn, and along a small tortuous canal which supplied. From such a vantage point one could see the church tower and the tile roofs of Ixtlahuaca to the east, and at a distance of about five kilometers, while to the north the small town of Jocotitlan was just recognizable as a series of white and red specks ~~on the green background~~. To the south, and within two kilometers were the white chapel and the rambling walls of a ~~somewhat~~ dilapidated hacienda. Within the cornfields of the village one came upon a tortuous ditch, in which a plentiful supply of turbid water was flowing, since it was the rainy season. A well worn path followed the small canal and led to the houses, all of which were situated so as to be conveniently supplied with water for washing clothing, and for every purpose except that of drinking. The latter was furnished by a deep well over which was an adobe building roofed with tile. A rope, tied to an earthenware vessel, provided the means of drawing the water. Both men and women worked in the fields but some of the women were to be seen washing clothing or wool in the stream, carding wool, spinning thread on crude spindles, or weaving cloth on simple looms tied to the roof-tree of the house. The houses ~~Small children, numerous dogs, and an occasional small pig~~, ~~tied by the hind leg to a stake~~ occupied the dorryard. The single-room houses built consisted of one room, of adobe blocks, with one door and perhaps another opening for light. They contained no furniture. Rush mats were on the floor or hanging on pegs on the wall. These took the place of tables, chairs andbeds. A simple stone hearth without a chimney was in one end, the smoke finding its way out under the open eaves. Several earthenware vessels of variable size, a three-legged flat-topped stone and stone roller for grinding corn, a flat earthenware platter, and a wooden ladle constituted the ~~complete~~ culinary equipment.

The occupation of the men was purely agricultural and pastoral. The women also worked in the fields, when they were not occupied with weaving clothing, carding wool, spinning or weaving. The only metal implements found in the entire pueblo consisted of sickles and machetes, these ~~latter serving the peaceful purposes of husbandry~~. There was no game and no hunting. Furthermore, the inhabitants had no firearms. No pottery was made here, nor was there any manufacturing activity of any kind in the two neighboring towns which provided the only convenient trading and social contacts with other native groups.

Cachi was poor. Its people had poor clothing and few belongings. Nevertheless it was essentially self-sufficient. The people produced their own food from the ~~out of their own~~ soil. They had corn, beans, small quantities of barley and wheat, and numerous other vegetable products, together with milk, eggs, pork and fowl. They were well fed, and in general they were healthy. The altitude of over eight thousand feet provided freedom from excessive heat and tropical insects, but the warm bright days permitted the growth of vegetation the year round. Thus there was no hunger. Such food as was not required in the village was sold or bartered for lime, cloth, pottery, mats, hats sombreros, blankets serapes, and shawls rebosos. In general, however, very little was produced in excess. Thus only necessities were procurable, and though tobacco was relished greatly its use was infrequent. Pulque, the fermented (and commonly ~~putrefied~~) juice of the almost ubiquitous magey, was easily available, and was generally used as a beverage by the men and boys.

There were no highways between Cachi and the towns in the vicinity. ~~In fact, there were no recognizable roads into Ixtlahuaca. It was~~

usually necessary to walk or to ride on a burro or horse to reach it. ~~An automobile ride across the fields from Ixtlahuaca was an adventure of questionable outcome.~~ (~~Doctor Flores at Ixtlahuaca, the only physician in the vicinity,~~ gave every assistance and on several occasions drove us to Cachi, showing an astonishing skill in going around, over and through pools of water and mud in the open plain. ~~The greater number of his medical visits outside Ixtlahuaca are made on horseback.~~ - Through the greater part of the year the automobile is a mark of distinction, rather than an article of utility. - The Indians walked or trotted, often carrying a load of sticks or other material several times their own bulk. The only horse in the village was the property of the chief.

No ¶ The visits of the Indians to the ~~neighboring~~ towns were limited to market day, and local or general fiesta days./ ~~The former, which~~ occurred once a week, provided an opportunity for seeing and perhaps purchasing or trading for articles from the city. In Ixtlahuaca merchants from Toluca spread their wares in open booths along the streets, while people from the countryside piled their products around them on the ground and offered them for sale or trade. However, the pervading atmosphere was not that of a market place but rather that of a gay bazaar. The social life of the neighborhood found its chief expression in these weekly gatherings. If something could be bought or sold a pretext was thus provided for a day of visiting and pleasure, in which commercial matters were mere incidents.

No ¶ More distant places were visited rarely. Only one of the persons used as subjects in Cachi, an old man of seventy, had ever been in Mexico City. He had traveled the entire distance on foot, ~~during the celebration of the fiesta of the Virgin of Gaudilupe.~~

The Rancheria el Colera is a small pueblo near Capulhuac about twenty-four kilometers southeast of Toluca and approximately fifty kilometers from Cachi. Its people and its community life were so similar to those of the village previously described that no points of significant differentiation were evident, except that the variety of food materials generally used was somewhat greater than that of the people of Cachi. This will be shown in the list of food samples on which analytical results have been obtained.

No mining or smelting of lead has been carried on in the State of Mexico according to information supplied by the federal Institute of Geology. No deposits of lead ores were known to exist in the vicinity of the two villages in which observations were made, though three obsolete documents granting claims for the extraction of argentiferous galena in the town lands of Aquipan, in the extreme south of the state, were found in the Department of Mines. The fate of these attempted mining developments is not recorded.

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~~The careful~~ Observation of the activities of the people in the two communities led to the recognition of only one opportunity for the artificial introduction of lead into their food. This came from their use of earthenware utensils, which will be shown to have been glazed with a lead compound. Considering the antiquity of pottery and lead glazing materials, this may not be regarded as a modern phenomenon. Some idea of its significance as an early example of the use of lead-containing commodities may be obtained from the data of this study.

Fifty-three subjects in Cachi, and forty-two in Colero were selected for study. Each subject was questioned as to his birthplace, age, occupation, visits away from the village, and illnesses. A cursory physical examination was made for the purpose of eliminating such as were ill, and a determination of the haemoglobin of the blood by Dare's instrument, a urinalysis, and blood ~~smears~~ films, were made on each subject. Fifty cubic centimeter samples of blood for analysis were obtained from thirty-four subjects in Cachi. In the collection of these samples ~~great~~ care was taken to avoid any contamination. The syringe and needles were sterilized in a small metal receptacle heated by an alcohol lamp. Distilled water had been carried along for the purpose. After ~~obtaining~~ the collection of each sample the syringe was washed out with well water, rinsed in distilled water and boiled in distilled water. From time to time additional distilled water had to be added to the sterilizer. At the end of the day's work, the residual water in the sterilizer containing the non-volatile accumulations from several sterilizations, was poured into a sample bottle for preservation and analysis.

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Gallon jugs for samples of urine and beverages, and quart jars for faeces and solid food materials, and small bottles for blood and other small samples had been prepared and sealed in the laboratory in Cincinnati, and had been shipped by rail to the nearest point. The final lap of their journey was made on the backs of burros. They were stored in a dry adobe house, from which they were given out to the subjects for immediate use and immediate return to the custody of the caretaker. Each subject was provided with an identification card which showed his name and number, the jugs and jars having been labeled correspondingly. At first difficulty was encountered in introducing the idea that the urine samples were to be provided by single individuals. In some instances the identification cards were passed to other members of the family of the subject in order to expedite the conclusion of the work and the obtaining of the fee. This was not so much an intentional deception, as a lack of understanding of what was desired. When the language difficulties of the situation are considered, and when some inkling of the absurdity of the entire situation from the point of view of the Mexican is appreciated, the misunderstanding is not surprising. On the whole, however, the collection of the samples was satisfactorily accomplished, with only the occasional mishap of mixing the urine of more than one person in a single container. In a few instances recorded in the data, the samples were so small that they were combined to make composite samples. The food samples were collected directly into the jars.

Upon the completion of the work, each sample was treated with from 5 to 10 c.c. of 40% formaldehyde which had been shown by analysis to be free of lead. The containers were sealed, packed in crates and shipped back to the Cincinnati laboratory for analysis. ~~Through the courtesy of customs offi-cials it was possible to have them inspected~~ Customs inspection was carried out in Cincinnati in the presence of a member of the laboratory staff. Thus no opportunity was given for the contamination of any of the materials from the time they left the Mexican

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Cincinnati laboratory for analysis. Through the courtesy of customs officials it was possible to have them delivered to the analytical laboratory without breaking the seal on a single container, the customs inspection having been made in Cincinnati in the presence of a member of the laboratory staff. Thus no opportunity was given for the contamination of any of the materials from the time they left the Mexican village until they arrived in the laboratory.

Tables ~~XVI~~ 1 to ~~XIII~~ 4, inclusive, show the analytical results which relate to foods materials. ~~present the data of the analytical observations.~~ Soil samples taken at random in the fields under cultivation (Table ~~XVI~~ 1) uniformly show small amounts of lead. Since there had been no opportunity for surface contamination of the earth by artificial means, these results give some idea of the natural lead content of the soil. No doubt there are wide variations in different parts of the earth, but wherever soil is produced by the leveling of mountains, some small quantities of lead may be expected to be found. Similarly, the water contains minute traces of lead. Table ~~XVII~~ 2 shows that the vegetation ~~has~~ absorbed small amounts of lead.

In the case of prepared foods (Table ~~XIX~~ 4) it is necessary to consider the opportunities for the introduction of lead from the use of pottery. Table ~~XVIII~~ 3 demonstrates the lead-glazed character of the pottery which was being used generally in the two pueblos. Certain of the animal products, such as eggs, fish, lizards and crawfish were obtained in a raw state and are not to be classified as prepared foods.

2

Table XVI

Lead in Soil and Water

Article	CACHI			COLERO		
	Quantity	~~Iod~~ Pb Found Mgs.	Pb Concen. Mgs/Kilo ~~in~~	Quantity	~~Iod~~ Pb Found Mgs.	Pb Concen. Mgs/Kilo
Well Water (drinking)	3500 c.c.	0.03	0.009/L	3900 cc	0.03	0.009/L
Water from Stream(washing)	3240 c.c.	0.00	0.00	3860 cc	0.03	0.009/L
Soil #1	50.00 Grams	0.22	4.44	50 [illegible] Grams	0.30	6.00
Soil #2	" "	0.08	1.60		0.03	0.60
Soil #3	" "	0.26	5.20			

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Table XVII

3

Natural Lead in Vegetation Used as Food Materials

Articles	CACHI Weight in Gms.	CACHI Pb.Found Mgs.	CACHI Pb mg/Kilo	COLERO Weight in Gms	COLERO Pb.Found Mgs.	COLERO Pb mg/Kilo
Wheat (dry)	99.40	0.04	0.40			
Wheat (green)	146.40	0.04	0.27			
Corn (dry	330.70	0.11	0.33			
Corn (green) #1	161.20	0.05	0.31	331.80	0.01	0.03-
Corn (green) #2	217.00	0.03	0.14			
Corn Stalk (green) #1	183.20	0.02	0.11	275.00	0.02	0.07
Corn Stalk (green) #2	215.00	0.01	0.05-			
Corn Husks (green)	227.20	0.06	0.26			
Peas (green)				291.20	0.01	0.03-
Pea Pods (green)				193.00	0.01	0.05-
Beans (dry)	273.00	0.11	0.40	175.40	0.07	0.40
Beans (Haba) (dry)				213.30	0.03	0.14
Beans (Haba) (green)	116.00	0.03	0.26	256.50	0.04	0.15
Pods (Haba) (green)	175.00	0.00	0.00	283.80	0.01	0.04-
Leaves (Haba) (green)	133.30	0.00	0.00			
Pears (green)				218.10	0.04	0.18
Apples (green)	249.50	0.03	0.12			
Peaches (green)	243.70	0.02	0.08	262.80	0.01	0.04-
Nopal #1	149.30	0.00	0.00	231.10	0.01	0.04-
Nopal #2	214.40	0.01	0.05-	128.60	0.03	0.23
Squash (green)	121.00	0.04	0.33	335.60	0.01	0.03-
Squash Plant				71.20	0.02	0.28
Radishes				54.80	0.01	0.18
Turnip Leaves				221.50	0.00	0.00
Peppers				32.00	0.03	0.94
Greens #1	85.70	0.00	0.00	224.60	0.01	0.05-
Greens #2				80.70	0.00	0.00
Capulin (type of cherry)				215.90	0.01	0.05-

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Table XVIII
4B

Lead in Pottery Used by Subjects

Sample	CACHI			COLERO		
	Weight in Gms.	~~Lead~~ Pb Found Mgs.	Percent	Weight in Gms.	~~Lead~~ Pb Found Mgs.	Percent
Glazed Dish	1.00	8.20	0.82	1.00	13.00	1.30
Glazed Dish				1.00	12.50	1.25
Unglazed Dish				1.00	0.10	0.01

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Table XIX

5

Lead in Animal Products and Prepared Food Materials

Articles	CACHI Weight in Gms.	CACHI Pb.Found Mgs.	CACHI Pb Mgs/Kilo	COLERO Weight in Gms.	COLERO Pb.Found Mgs.	COLERO Pb Mgs/Kilo
Atole - (barley and corn gruel)	417.50	0.00	0.00	409.70	1.70	4.15
Corn in Lime Solution	445.00	0.04	0.09	544.00	0.10	0.18
Corn ground for Tortillas	117.20	0.02	0.17	265.70	0.03	0.11
Bread				73.70	0.07	0.95
Tortillas	119.40	0.07	0.59	224.80	0.08	0.35
Tamales (corn)				283.30	0.01	0.04
Chicken				419.80	0.00	0.00
Eggs - Hen and Turkey	503.40	0.00	0.00	471.50	0.01	0.02
Boiled Pork	411.70	0.03	0.07	492.10	0.00	0.00
Pork Sausage				73.80	0.02	0.27
> Lard (pork)				54.70	0.00	0.00
Beef				121.80	0.02	0.16
Chili (with meat)				324.40	0.15	0.46
Cheese				84.40	0.00	0.00
Dried Fish				26.50	0.04	1.51
Fresh Fish				80.90	0.02	0.24
Ajolotes (lizard)				207.80	0.02	0.10
Craw Fish				186.90	0.14	0.75
Common Salt				204.60	0.21	1.02
Candy (local type)				277.60	0.08	0.29
Pulque	3300 cc	0.14	0.04	Sample Lost		
Aguamiel Wine				3760 cc	0.06	0.02

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Thus any lead found in them is of natural origin. In fact, only two of the articles listed in Table XIX, show amounts of lead which indicate the likelihood of significant contamination, namely, the pulque which probably took up some of its lead from earthenware vessels, and the atole, one sample of which was grossly polluted with lead. The latter circumstance may have been due to the unrecognized presence of small fragments of the earthenware jar in which it had been kept, since such jars are very fragile.

5, 6, 7, 8, and 9
Tables XX, XXI, XXII, XXIII, and XIV, display the lead findings in the two groups of subjects. Only eleven of the thirty-two blood samples showed the presence of lead, and in these the quantities were small, but measureable. Because of the minuteness of the quantities of lead, which were at the lower limit of analytical sensitivity ~~estimation~~, the entire volumes of the last five positive and the last three negative samples as finally prepared for the colorimetric determination, were preserved for re-examination. (Twenty-three samples had been completed and the solutions had been discarded before this procedure was decided upon. The two sets of combined samples were evaporated down to the required amounts for colorimetric comparison and a re-estimation of the total lead was made. This same process was employed in checking the quantities of lead in all other types of samples, the results appearing in Table 9 XXIV. Thus, despite the small~~ness of the~~ quantities of lead involved in the entire series of analyses, there can be no doubt of the presence of lead where it is reported to have been found.) It is certain that the lead

Does this fact need to be enclosed in brackets?

Table 6 XX

Distribution of Subjects According to Lead in the Blood

Lead in Milligrams per 100 Gms. Blood	Number	Percentage
0.00 -	21	65.6
0.01 - 0.02	6	18.8
0.03 - 0.04	2	6.3
0.05 - 0.06	1	3.1
0.07 - 0.08	1 *	3.1
0.25	1 *	3.1
Total	32	100.

* Unusually small samples. Quantitation results subject to uncertain.

7

Table XXI

Distribution of Subjects According to ~~Amounts~~ milligrams of Lead ~~in the~~ per liter of Urine

Milligrams of lead ~~or~~ per Liter of Urine	COMBINED GROUPS Number	COMBINED GROUPS Percentage	CACHI Number	CACHI Percentage	COLERO Number	COLERO Percentage
0 - 0.009	37	45.7	19	45.2	18	46.2
0.010 - 0.019	26	32.1	10	23.8	16	41.0
0.020 - 0.029	10*	12.4	8*	19.0	2	5.1
0.030 - 0.039	4	4.9	2	4.8	2	5.1
0.040 - 0.049	3	3.7	2	4.8	1	2.6
0.050 - 0.059						
0.060 - 0.069						
0.070 - 0.079						
0.080 - 0.089						
0.090 - 0.099						
0.100 - 0.109						
0.110 - 0.119						
0.120 - 0.129	1**	1.2	1*	2.4		
Totals	81	100.00	42	100.00	39	100.00
Mean	0.0138 ~~± 0.0008~~		0.0148 ~~± 0.0012~~		0.0127 ~~± 0.0010~~	
Probable Error of Mean	±0.0008		±0.0012		±0.0010	
Standard Deviation	±0.0105		±0.0114		±0.0095	

* These include two composite samples made up of the urines of two groups of children.

** Omitted in calculation of mean.

Table XXII

8

Distribution of Subjects According to Milligrams of Lead per Gram Ash of Faeces

Milligrams of lead per Gram of ash	COMBINED GROUPS Number	COMBINED GROUPS Percentage	CACHI Number	CACHI Percentage	COLERO Number	COLERO Percentage
~~Nil~~ 0 - 0.019	28	36.9	19	47.5	9	25.0
0.020 - 0.039	21	27.6	9	22.5	12	33.3
0.040 - 0.059	13	17.1	6	15.0	7	19.5
0.060 - 0.079	5	6.6	4	10.0	1	2.8
0.080 - 0.099	4	5.3	2	5.0	2	5.5
0.100 - 0.119	~~0~~	~~0.0~~	~~0~~	~~0.0~~	~~0~~	~~0.0~~
0.120 - 0.139	2	2.6	~~0~~	~~0.0~~	2	5.5
14						
16						
0.18 - 0.199	1*	1.3	~~0~~	~~0.0~~	1	2.8
20						
22						
24						
0.26 - 0.279	1*	1.3	~~0~~	~~0.0~~	1	2.8
0.28 - 0.299	1*	1.3	~~0~~	~~0.0~~	1	2.8
Totals	76	100.0	40	100.0	36	100.0
Mean	0.0347 ~~± 0.0022~~		0.0305 ~~± 0.0026~~		0.0397 ~~± 0.0037~~	
Probable Error	±0.0022		±0.0026		±0.0037	
S. D.	±0.0280		±0.0243		±0.0312	

*Omitted in calculation of the mean.

Table XXIII

Distribution of Subjects According to Lead Found in Faeces

Milligrams of lead per sample of faeces	COMBINED GROUPS		CACHI		COLERO	
	Number	Percentage	Number	Percentage	Number	Percentage
~~Nil~~ 0 - 0.019	8	10.5	6	15.0	2	5.5
0.020 - 0.039	7	9.2	5	12.5	2	5.5
0.040 - 0.059	9	11.8	8	20.0	1	2.8
0.060 - 0.079	7	9.2	5	12.5	2	5.5
0.080 - 0.099	4	5.3	2	5.0	2	5.5
0.100 - 0.119	9	11.8	4	10.0	5	13.9
0.120 - 0.139	7	9.2	1	2.5	6	16.7
0.140 - 0.159	6	7.9	1	2.5	5	13.9
0.160 - 0.179	2	2.6	2	5.0	0	0.0
0.180 - 0.199	3	4.0	2	5.0	1	2.8
0.200 - 0.219	3	4.0	2	5.0	1	2.8
0.220 - 0.239	1	1.3	0	0.0	1	2.8
0.240 - 0.259	3	4.0	1	2.5	2	5.5
0.260 - 0.279	2	2.6	0	0.0	2	5.5
0.280 - 0.299	0	0.0	0	0.0	0	0.0
0.30 - 0.319	1	1.3	1	2.5	0	0.0
0.40 - 0.439	3	4.0	0	0.0	3	8.3*
1.00 -	1	1.3	0	0.0	1	2.8*
Totals	76	100.0	40	100.0	36	100.0
Mean	0.1078 ~~± 0.0059~~		0.0900 ~~± 0.0077~~		0.130 ± ~~0.0083~~	
Probable error of mean	±0.0059		±0.0077		±0.0083	
Standard deviation	±0.0741		±0.0725		±0.0700	

* Omitted in calculation of the means.

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Table XXIV

10

Summation of Analytical Results as Compared to Amounts Obtained by Composite Analyses

Description	CACHI Number of Samples	CACHI Sum of Individual Findings	CACHI Composite Analysis	COLERO Number of Samples	COLERO Sum of Individual Findings	COLERO Composite Analysis
~~Blood Samples~~ Blood Samples - Pos.	5*	0.05	0.08			
~~Blood Samples~~ - Neg.	3*	0.00	0.00			
~~Urine Samples~~ Urine Samples - Pos.	22*	0.78	0.85	32	1.41	1.51
~~Urine Samples~~ - Neg.	3*	0.00	0.00	7	0.00	0.00
fluids ~~Faeces Samples - Neg.~~	~~0**~~	~~-~~	~~-~~	~~0~~		
~~Food Samples~~ Food Samples - Pos.	19	0.97	0.93	34	3.17	2.97
Food Samples - Neg.	7	0.00	0.04	9	0.00	0.06
Total	72	2.82	2.92	118	10.73	10.29

* Material from other samples was discarded. ~~when individual analysis was completed, the plan to do composite analyses developing later.~~

** Only three negative results were obtained on faecal samples. ~~The material was discarded before the adoption of the plan to do composite analyses.~~

found by analysis was in the blood as withdrawn from the veins of the subjects, for any suspicion that contamination may have occurred is ~~completely~~ dispelled by the fact that the three samples of residual distilled water from the sterilizer ~~[illegible]~~ failed to show traces of lead.

Table ~~XXI~~ 6 detailing the analytical results obtained on the urinary samples, shows the mean values of the lead excretion per liter of urine for each group as well as for the combined group of subjects. Here, again, the results were low but the volumes of the individual samples were so large that the amounts of lead generally found were within the limits of accurate measurement. The volume of the average sample was over three liters, many being four, and only a few less than two liters. The accuracy of estimation of the smaller amounts is attested by the result of the composite analysis which appears in Table ~~XXV~~ 9. The urinary excretion of lead is of the same magnitude in the two groups of subjects, as shown by the calculated mean~~s~~ values. Despite the comparatively small numbers of subjects the means are so stable as to indicate only a small variability in the experience of the subjects as regards lead absorption. The excretion of lead in terms of milligrams of lead per gram of ash in the faeces, (Table ~~XXII~~ 7), shows a slightly greater variability, but the two groups of subjects are similar in this regard, and may not be differentiated statistically. A

Stop here

comparison of these mean values with those obtained from the study of the medical student (cf. Tables VII and VIII), brings out the surprising fact that they are of the same order of magnitude. Evidently the ingestion of lead by persons living under these natural and primitive conditions, is not widely divergent from that experienced by certain individuals in an American city. The evidence provided in Table XXIII leads to the same condlusion. The quantities of lead actually found in the samples reach a mean value of 0.108 milligrams of lead for the entire group of subjects. On the whole, the single samples represent not more than one day's alimentary output, while the lead content may be assumed to be something less than that ingested during the previous day. In these terms the mean daily ingestion of lead amounts to a little more than one tenth of a milligram of lead. This value of 0.108 ~~milligrams~~ mgm. in the Mexican subjects is to be compared with the value of 0.187 arrived at by similar methods in the case of American subjects. A slightly different basis of comparison may be made by calculating the mean daily output of lead in both urine and faeces. Assuming that the mean lead content of the faecal samples constitutes the alimentary excretion for a day, and that approximately two liters of urine are voided daily, the average Mexican excretes approximately 0.14 milligrams of lead per day, as compared to 0.33 milligrams for the American. The unavoidable conclusion to be drawn from these facts is obvious. Despite all the opportunities for the artificial contamination of food materials with lead in American cities, a large proportion of lead which is ingested by the average American is derived from natural sources.

A classification of the Mexican subjects on the basis of their ages, as portrayed in Table XXV, shows that a large number of children were included in the groups. An opportunity is thus afforded for the comparison of these children with the adults of their own type, and with American children. Table XXVI gives the analytical data for children up

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1

Table ~~XXV~~

Distribution of Subjects According to Age

Age in Years	Combined Groups	Cachi	Colero
5 - 9	30	16	14
10 - 14	13	2	11
15 - 19	7	4	3
20 - 24	4	2	2
25 - 29	14	8	6
30 - 34	6	5	1
35 - 39	6	5	1
40 - 44	4	2	2
45 - 49	1	1	0
50 - 54	2	1	1
55 - 59	2	2	0
60 - 64	3	2	1
65 - 69	1	1	0
70 -	2	2	0
Totals	95	53	42

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Table XXVI

Distribution of Children ~~as~~ According to Lead Found in Faeces, Lead in Milligrams per Gram Ash of Faeces, and Lead in Milligrams per Liter of Urine

Lead Findings Milligrams	Number of Subjects as to Lead Found in Faeces			Number of Subjects as to Lead in Mgs/Gm Ash			Number of Subjects as to Lead in Mgs/L.Urine		
	Cachi	Colero	Combined	Cachi	Colero	Combined	Cachi	Colero	Combined
Nil0 - 0.019	2	2	4	5	5	10	9*	12*	21*
0.020 - 0.039	2	2	4	4	5	9	5	4	9
0.040 - 0.059	4	1	5	1	2	3			
0.060 - 0.079	2	1	3	1	1	2			
0.080 - 0.099	1	1	2	1		1			
0.10 - 0.119		2	2						
0.12 - 0.139		1	1		1	1			
0.14 - 0.159		2	2						
0.16 - 0.179									
0.18 - 0.199		1	1		1	1			
0.20 - 0.219									
0.22 - 0.239		1	1						
0.24 - 0.259	1		1						
0.26 - 0.279		1	1						
Totals	12	15	27	12	15	27	14	16	30
Means (Combined Groups)	0.0881 ~~± 0.0093~~ ±0.0093			0.0396 ~~± 0.0053~~ ±0.0053			** 0.0153 ~~± 0.0014~~ ±0.014		
S. D.	±0.0712			±0.0409			±0.0114		

* Only six of these are nil, two from Cachi and four from Colero.
**Calculated after a wider distribution of findings.

to nine years of age. The numbers of subjects are too small to permit statistical treatment of the individual groups, but the means for the total number of children from the two villages are stable. The means are not ~~significantly~~ sufficiently different from those of the entire groups to justify calculations on the adults alone. On the other hand, the urinary lead excretion of these children is significantly lower than that of the American children, though their faecal excretion, while considerably lower, is not significantly so from a statistical point of view. The importance of the observations on the Mexican children arises from the fact that it is not necessary to consider the possibility of any sources of lead ingestion external to their pueblo. They had spent their entire lives up to that time in the immediate vicinity of their native village.

The examination of blood smears made from these subjects establishes a fact which is of some consequence in relation to lead absorption. Much discussion has concerned itself with the question of whether stippling of the erythrocytes occurs in normal persons. Table XXVII answers the question conclusively and affirmatively. There can be no question of any relationship between significant lead absorption and the presence of stippled erythrocytes in the blood of these subjects. On the other hand, there is a ~~significant~~ wide difference in the people of the two villages in this regard. For some unexplainable reason a considerable proportion of the blood smears from Cachi show numbers of stippled erythrocytes which would be generally regarded as

Table XXVII

Distribution of Subjects ~~as~~ according to Stippling of Erythrocytes

Number of Stippled Erythrocytes per 50 Fields	CACHI		COLERO	
	Number	Percentage	Number	Percentage
0 - 3	28	46.7	38	91.3
4 - 7	12	20.0	2	4.3
8 - 11	3	5.0	1	2.2
12 - 15	3	5.0		
16 - 19	5	8.3		
20 - 23	1	1.7-		
24 - 27	1	1.7-		
28 - 31	3	5.0		
32 - 35				
36 - 39				
40 - 43	1	1.7-		
44 - 47				
50 - 53	1	1.7-		
54 - 57			1	2.2
74 - 77	2	3.3		
Total	60	100	42	100

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Table XXVIII

Distribution of Subjects According to Haemoglobin of Blood

Haemoglobin Reading (Dare)	CACHI Number	CACHI Percentage
~~60 - 64~~		
65 - 69	0	0
70 - 74	3	5.1
75 - 79	17	28.8
80 - 84	13	22.0
85 - 89	15	25.4
90 - 94	9	15.3
95 - 99	1	1.7
100 -	1	1.7
Totals	59	100.

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of diagnostic significance, under conditions of lead exposure. The smears from Colero were mostly negative, and uniformly low. The presence of secondary anemias in the inhabitants of Cachi might be expected to produce such a result. However, the subjects in both villages were healthy, and the haemoglobin determinations in Cachi, shown in Table XXVIII, do not suggest the existence of any considerable incidence of anemia. Furthermore, there is no correlation between the amount of stippling and the haemoglobin reading. These facts lead to the conclusion that stippling occurs as a normal phenomenon/ of unknown physiological significance. This statement of fact must not be interpreted as a denial of the practical value of blood examinations in the case of workers in the lead trades. Data which will be shown later demonstrate the importance of such observations in obtaining presumptive evidence of lead absorption. Nevertheless, considerable caution must be exercised in drawing conclusions from such information, even under the most suggestive conditions.

KE 0014463

Chapter III

The Sources of Lead Absorption in the Modern Community

The uniform occurrence of lead in the excreta of normal individuals indicates a general distribution of lead compounds in the normal human environment. The quantities of lead in the urine are so small as not to be demonstrable by the analytical methods employed by most of the earlier investigators. Thus, there is no adequate basis for an assumption that this is a phenomenon of modern life. Evidences to the contrary are to be found in certain observations of the lead content of food and drink. As early as 1881, Gautier determined the lead content of many food materials, by satisfactory chemical methods, and concluded that the average Frenchman was ingesting approximately half a milligram of lead daily. In his opinion the principal source of lead was to be found in cooking utensils and preserving cans. Other facts, mostly of a fragmentary character, tend to demonstrate that such factors were not the only ones involved. Fuller reference to these matters will be made later. But it need not follow that present conditions are the same qualitatively or quantitatively. The modern technique of handling food is very different from that of the nineteenth century, while many other matters of everyday life have seen revolutionary changes. Therefore it is necessary to examine the conditions in the modern community in some detail.

KE 0014464

We have chosen to approach this question by a less laborious method than that of systematically studying the lead content of foods and other materials with which the individual has contact. It appeared more advantageous and more interesting from a physiological point of view, to observe human subjects under certain sharply defined variations in environment, thereby obtaining simultaneous information as to the environmental factors and the response to them. A study of the lead excretion of infants and children was made on the possibility that the limited length and quality of their experience might be associated with an obvious limitation of their contacts with lead. Observations on adults under carefully controlled conditions supplied further variants.

1. Lead Excretion in Infants and Children.

Children were taken at random from various services in a children's hospital, with care to exclude such as were suspected or known to have had exposure to lead compounds or a history of pica. Those with acute illness were also avoided. In so far as it was possible, samples of urine and faeces were collected directly into the containers, through In some instances this could not be done. The precautions taken were such as to avoid the likelihood of contamination of the materials with any lead-bearing materials.

Table IV shows the ages, the grounds for admission to the hospital, and the lead findings in this group of children, together with ~~Table V contains~~ the mean values for the excretion of lead in

Frequency Distribu

Children Hospital Diet
Lead
Mgs./g of 7 =0.080 ±.005

	f	x	fx	fx^2
0-.029	3	0	0	0
.03-.059	10	1	10	10
.06-.089	9	2	18	36
.09-.119	6	3	18	54
.12-.149	3	4	12	48
.15-.179	2	5	10	50
.18-.209	1	6	6	36
	34		74	234

$$\frac{74}{34} \times .03 + .015 = .0803$$

$$\frac{74}{34} = 2.176470\overset{2}{5} = 4.7370284$$

$$\frac{234}{34} = 6.88235 - 4.73702 = 2.14533 \leftarrow \sqrt{\ } = 1.4646$$

$$S.D. = .03\sqrt{\frac{234}{34} - \left(\frac{74}{34}\right)^2} = \pm .0439$$

$$\frac{.67449 \times .0439 = .0296101}{\sqrt{34}} = \pm .00508$$

Mean = 0.0803
S.D. = ±0.0439
P.E.

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(1)

Table IV

Lead Excretion in Normal Children

Hospital Identification No.	Description of Case or Diagnosis	Age in Years	LEAD IN FAECES Mgs. Found	LEAD IN FAECES Mgs/Gm Ash	LEAD IN URINE Mgs. Found	LEAD IN URINE Mgs./Liter
90	Orthopedic Treatment	9	0.30	0.06	0.17	0.17
245	Chorea	8	0.27	0.09	0.08	0.06
970	Cardiac Lesions	7	0.27	0.03	0.11	0.09
✓ 2130	Post-Operative Convalescence	5	0.10	0.03	0.23	0.08
2330	Cardiac Lesion	10	0.38	0.10	0.13	0.07
2504	Orthopedic Treatment	12	0.61	0.08	0.20	0.08
2582	Convalescent Polio-	4	0.05	0.005	0.14	0.09
2783	Orthopedic Treatment	4	2.22	0.31	0.11	0.13
2875	Convalescent Fracture	4	0.62	0.14	0.06	0.07
3043	Astragalectomy	9	0.14	0.07	0.10	0.06
3091	Osteomyelitis	11	0.42	0.08	Nil	Nil
3119	Post-appendectomy	7	0.10	0.13	0.11	0.08
3337	Eczema	1	0.37	0.07	0.20	0.18
3377	Chronic Appendicitis	14	0.09	0.03	0.24	0.08
3387	Osteomyelitis	7	0.53	0.06	0.13	0.07
3528	Mastoiditis	6	0.21	0.05	0.18	0.09
3531	Dietary Regulation	0.6	0.26	0.03	0.18	0.11
3532	Oesophageal Stricture	7	1.57	0.19	0.04	0.02
3604	Chorea	11	0.29	0.11	0.37	0.07
3691	Post-appendectomy	11	0.45	0.05	0.24	0.11
3695	Osteomyelitis	10	0.14	0.01	0.12	0.07
3698	Post-appendectomy	12	0.41	0.06	0.17	0.05
3703	Anemia (type?)	5	0.43	0.14	0.10	0.04
3706	Post-appendectomy	13			0.22	0.08
3726	Otitis media - nephritis	12	0.17	0.03	0.17	0.17
3763	Arthritis	6	0.10	0.01	0.18	0.07
3779	Post-appendectomy	12	0.28	0.07	0.13	0.04
3780	Convalescent Fracture	12	1.28	0.15	0.29	0.09
3846	Alkaptonuria	0.25	0.24	0.05	0.15	0.10
3866	Convalescent tonsillectomy	8	0.23	0.15	0.11	0.39
3874	Post-appendectomy	11	0.60	0.11	0.20	0.12
✓ 3887	Convalescent burn	6	0.39	0.04	0.05	0.03
3901	Mastoiditis	15	0.24	0.06	0.03	0.04
3967	Chorea	8	0.23	0.03	0.23	0.11
4020	Orthopedic Treatment	7	0.70	0.11	0.13	0.12
4026	Tonsillectomy	8	0.90	0.11	0.09	0.10
	Mean			0.080		0.085
	Probable Error of Mean			± 0.005		± 0.004
	Standard Deviation			± 0.044		± 0.038

the faeces and urine. The calculation of faecal excretion in terms of the total ash is not entirely justified on a physiological basis, for reasons which will appear later. However, it is a reasonably satisfactory arbitrary basis for quantitative comparison. In this case it is necessary to use some such means, for the reason that the faecal samples are not comparable on a, time basis base.

The constancy in the lead excretion in these children is sufficient evidence of the general and unavoidable character of exposure to lead compounds. Moreover, the magnitude of their lead excretion as compared to that of adults suggests either that lead is excreted more readily by the young, or that time is not an important factor in influencing the extent of absorption under present conditions of exposure to lead compounds.

It is worthy of note that none of these children showed symptoms which gave even the vaguest suggestion of lead intoxication. One of them had been breast-fed from birth. Thus it was evident that the possible sources of lead must be extended to include the suckling period and the gestation period. Accordingly the lead content of human milk was investigated in a limited manner. The results obtained may not be regarded as a representative cross section of the normal situation. They merely demonstrate that the ingestion of lead from this source may and does occur.

The milk was obtained by manual expression, each subject having been instructed by visiting nurses in the matter of cleanliness and general technique. The several small samples were collected and delivered fresh to the laboratory, where they were kept until a considerable volume had been obtained from each

Table V

Lead Content of Human Milk

Subject No.	Volume of Milk in c.c.	Lead Found in Mgs.
1	2031	0.05
2	1936	0.10
3	2806	0.09
4	1280	0.04
5	2858	Nil

subject. All (of) the subjects were housewives, with entirely negative histories in such matters as occupational exposures to lead, recent illnesses, and recent ~~sources~~ courses of medication.

Table V presents the results of the analyses.

Our data on lead absorption during gestation are confined to those obtained on experimental animals, under variable conditions of lead exposure. As such they do not apply to the present matter except in so far as they show that lead absorption in the pregnant animal is associated with lead absorption by the foetus. However, they furnish presumptive evidence that human beings may be born with lead in their tissues.

Insert Table II

2. Lead Ingestion and Lead Excretion in a Normal Adult.

A healthy medical student was selected as a subject for daily observations over a long period of time. His understanding of the character of the problem provided the intelligent care and cooperation required for prolonged study. He kept a diary of his activities and movements about the city and the College of Medicine, in which he also recorded his food intake together with its source. Except for specific instructions from time to time, he selected his food according to his own wishes, and but for conditions imposed for experimental reasons, his entire life was that of a normal junior in the College of Medicine.

The results obtained over a period of a year are graphically illustrated in Figures 1 to 7.

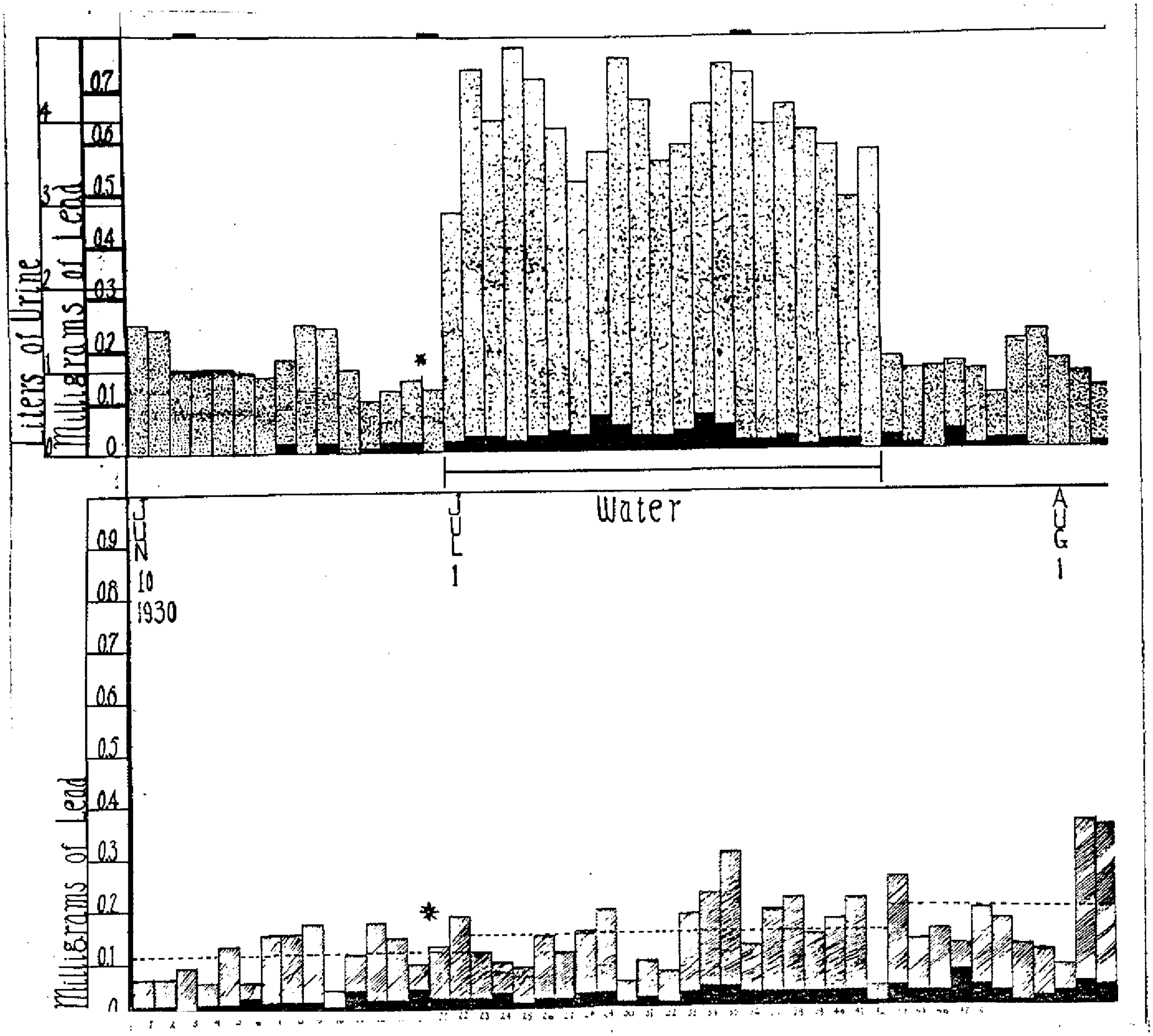

Fig. 1. Lead Excretion in a Normal Subject

The blocks represent consecutive daily observations. The small solid black blocks at the top indicate lead determinations on samples of 50 c.c. of blood. They do not extend into the field of the graph for the reason that the quantities of lead found were insufficient for accurate measurement. The upper section illustrates the urinary findings, the stippled area indicating volume of urine, the solid block the lead found in mgs. In the lower section the cross-hatched portions represent lead found in the faeces, while the solid black gives the lead in mgs. per gram of ash in the faeces. The dotted line records the average levels of faecal excretion of lead for the periods over which it extends.

* The observations made from the fifteenth to twentieth days inclusive have been omitted on account of accidental loss of the urinary samples for this period.

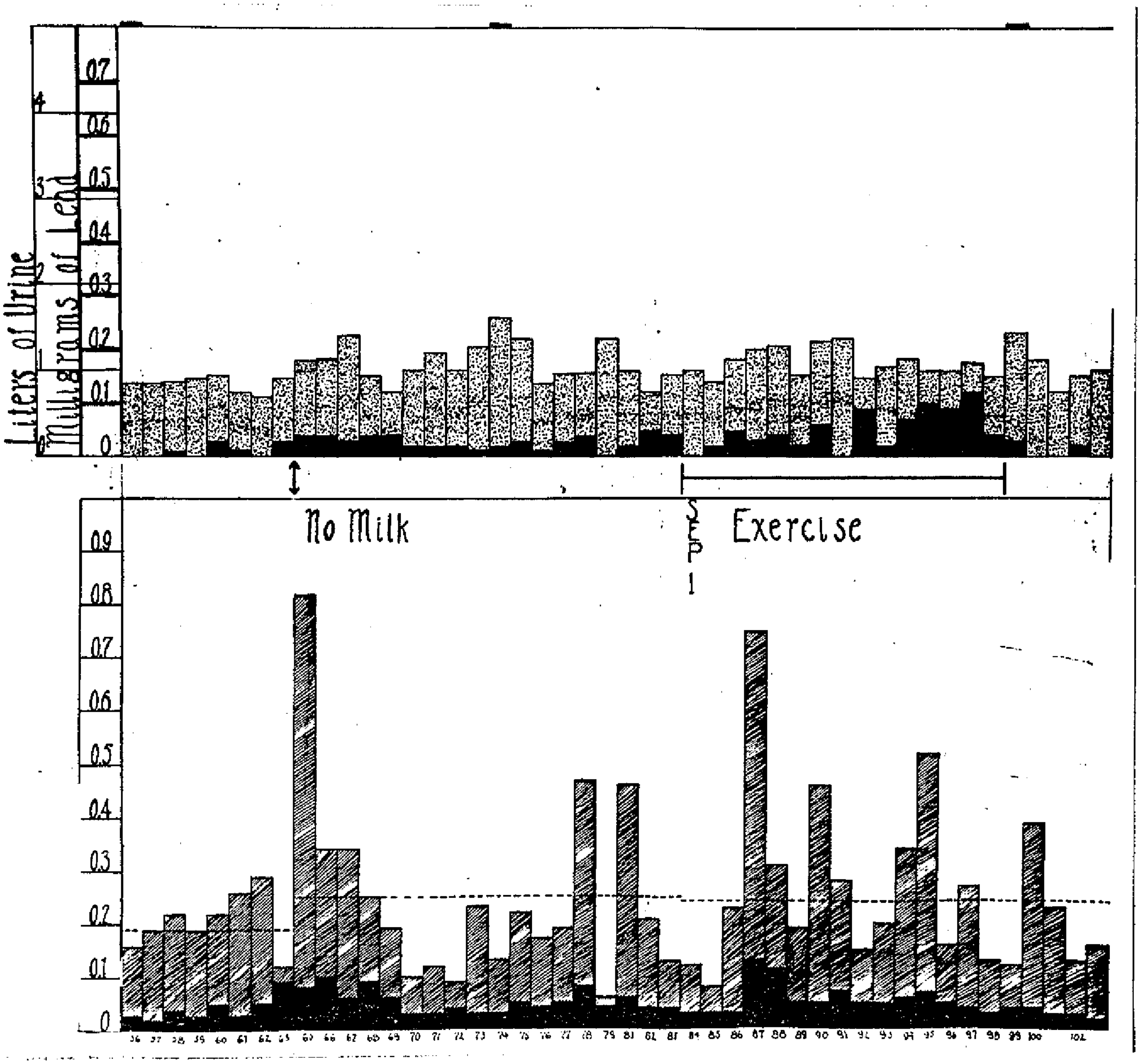

Fig. 2. Lead Excretion in a Normal Subject

The blocks represent consecutive daily observations as an uninterrupted continuation of Fig. 1.

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Three matters of special note may be seen in Figure 1. The urinary excretion of lead at the start is almost negligible, but when an increase in urinary volume is brought about by increased water intake it becomes significant, though variable from day to day. The faecal excretion of lead starts out on a much higher level than the urinary, and is subject to wider variation. It is clear that these variations are not referable entirely to variability of the mass of material excreted, for if such were the case the milligrams of lead per gram ash of faeces would be much more nearly constant. (The weight of ash is not an entirely reliable measure of the quantity of faeces, but experience has shown it to be the most generally satisfactory manner of expressing quantity.)

Figure 2 shows the introduction of two changes in the activities of the subject. He was instructed to discontinue the two quarts of milk which it had been his daily custom to take. ~~ly.~~ A slight brief rise in the urinary excretion of lead coincides with the day of discontinuance of milk. The faecal excretion also shows an elevation, with irregularly spaced, very high peaks. That neither of these changes is directly due to the elimination of milk from the diet will appear later.

Then daily vigorous exercise was carried out for three weeks. There is a definite rise in the urinary excretion, with resumption of the former level on the cessation of exercise. On the basis of the preceding rate of urinary excretion one would certainly ascribe this change to the influence of exercise.

KE 0014473

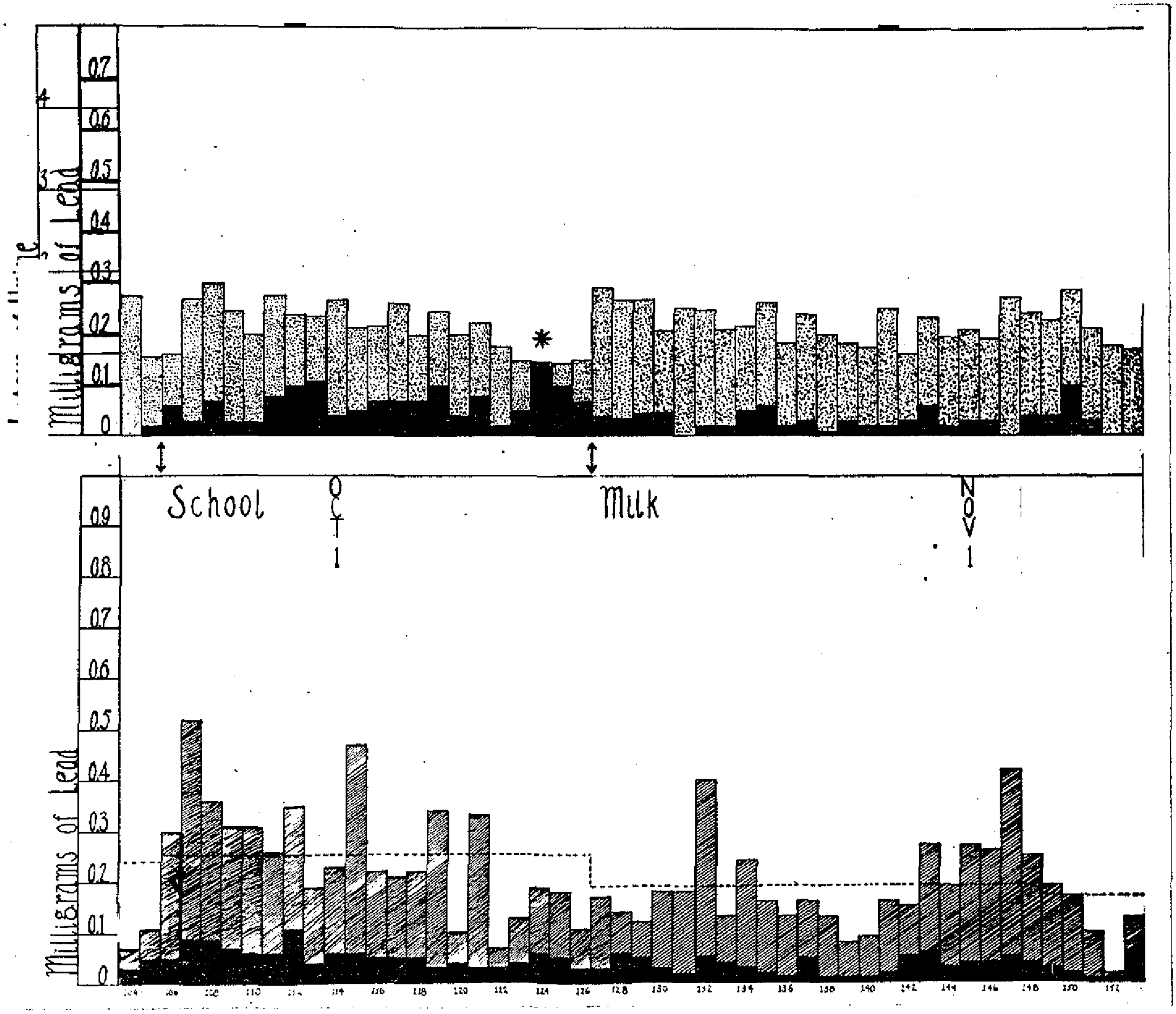

Fig. 3. Lead Excretion in a Normal Subject

The blocks represent consecutive daily observations as an uninterrupted continuation of Figures 1 and 2.

* This result of 0.14 mg. is an entirely abnormal one. The concentration of lead in the sample is 0.22 mg. per liter, and is higher than any obtained in the entire series of observations. Without doubt it is due to the contamination of the sample in some manner.

However, a similar rise in the urinary excretion of lead, without a corresponding change in the experimental procedure, as shown in Figure 3, casts considerable doubt upon the validity of such an enterpretation. In fact the general level of urinary excretion is notably high during the entire period represented in Figure 3. The explanation of this situation may be found by examining the faecal output of lead from the beginning of the observations through Figure 3. Beginning with the 54th day of observations (Fig. 1) and continuing up to the 149th day (Fig. 3) there is a maintained high level of faecal lead excretion such as is not shown in any other normal period of the study. This suggests the existence of a factor which is so much larger than any other in its influence upon lead excretion in both faeces and urine as to completely mask the effects of other experimental measures. <u>This factor is ~~associated with~~ the quantity and quality of ingested food</u>. It may be noted that the faecal excretion of lead shows wide

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Footnote: The very high figure obtained on the 124th day is entirely unlike any other result obtained during the entire study, and hence is probably in error. This figure of 0.14 mg. in 630 c.c. of urine represents a concentration of 0.22 mg. of lead per liter of urine. Such a concentration is not found in the urines of normal subjects, and it does not occur again in this subject, even when lead was administered for experimental purposes. It must be the result of contamination of the sample at some point in its collection or analysis.

KE 0014475

fluctuations from day to day, without any exact correspondence with the daily level of urinary lead excretion. On the whole, however, periods of several days in which the faecal excretion is high, are associated with corresponding high periods of urinary lead output. The significance of the wide fluctuations as well as of the generally large magnitude of the faecal excretion becomes apparent in the observations shown in Figure 4. Thus it is only necessary to point out that the notes kept by the subject indicate that for the periods of time represented in Figure 2 and the first half of Figure 3, the food intake was practically doubled as compared with that of the period shown in Figure 1. This was the result of longer working hours, shorter hours of rest, and changes in food sources. During the observations of Figure 1 the subject was at rest. At the beginning of Figure 2 he began to exercise daily to a moderate degree. On September 1st (Fig. 2) he began working on the hospital obstetrical service, being on call day and night. At the same time he took vigorous exercise by playing tennis through the greater part of the afternoon. On September 15th he began working on the hospital receiving ward. During this period vaccination against typhoid fever resulted in a severe reaction (first injection) with an evening temperature of 103° F. on two successive days. On September 23rd regular classes in the Medical College began, with the necessity for establishing a new routine. During this entire period the gross solid food intake was high not only as a result of activities, but also as a consequence of the discontinuance of two quarts of milk daily which had been an important item of diet previously.

Just how much direct effect on the lead excretion was produced by the discontinuance of milk and by exercise cannot be determined. A glance at the high findings during the absence of milk from the diet and at the lower results coincident with a return to the use of milk suggests a cause and effect relationship. In terms of the observations and conclusions of Aub and his associates[2], this might be thought to denote a steady depletion of the calcium stores of lead in the body, with the simultaneous elimination of greater amounts of lead during a period of low calcium intake, with an exactly opposite effect during a period of higher calcium absorption. Obviously, fatiguing exercise would be expected to increase the first effect. As a matter of fact, we cannot assume ~~that~~ either of these influences ~~can be assumed to have been~~ was exerted ~~to~~ any ~~important~~ great degree, because of the overshadowing ~~greater~~ effect of the ~~ingestion of~~ larger amounts of lead which were ingested when the total food intake was increased.

The lead content of the food, as shown in Figure 4, was obtained by having the subject collect an exact duplicate of every meal during the period of such observations. For the greater part of the entire period of food analyses, no attempt was made to determine the lead content of specific foods. The entire bulk of three meals was treated as a single sample and analyzed, each meal having been collected in a quart glass jar. Because of the laborious character of the analytical work, such analyses were purposely omitted in the initial periods shown in Figures 1, 2 and 3. We now wished to study accurately the influence of administered lead on the rate of excretion. A double purpose was thus served in beginning the food analysis on the same date that we began to administer lead.

On the day indicated by the first small arrow, the subject was given 1 mg. of lead as a solution of lead chloride in 50 c.c. of distilled water not less than half an hour before the noon meal. Every day for ten days the dose was repeated in the same manner, the conclusion of this period being marked on the graph by the second small arrow. The response to this small dose was immediate in the case of the urinary excretion, with a twenty-four hour lag in the faecal excretion. The urinary excretion may be seen to remain high during the period of experimental ingestion of lead and for four days thereafter. The faecal lead excretion, on the contrary, dropped off to a normal level in forty-eight hours, i.e. as soon as the alimentary tract emptied itself of unabsorbed lead.

The third small arrow indicates the termination of the time period for which the calculations of the inset table were made.

Figure 5 carries on the daily observations without a break in continuity, showing the effects of the daily ingestion of 5 mg. of lead in the form of the chloride, for six days. The first two small arrows delimit the period of lead administration, while the third marks the end of the time over which the data of the inset table were obtained. The three plateaus in the graphic representation of the lead in the food of the subject arise from the fact that for these three periods, the weeks supply of each article of food was combined into a single sample for analysis. The total lead found in all such samples

KE 0014478

Again, the response of the urinary excretion was prompt, and again it was sustained, this time for a longer period than that shown when the dose was smaller. The faecal excretion dropped off to almost its normal level in forty-eight hours, just as before. (The faecal excretion of lead during the period of ingestion and for two days thereafter is so large as to require a very much increased area for its graphic representation. For this reason the trend of the results has been indicated and the exact quantity of lead found has been noted at the top of the incomplete block.)

The results set forth in these two figures are so clean-cut as to require little clarification. They are so significant, however, as to justify some emphasis. First, the quantity of lead in the food is remarkably high. There was no reason to doubt the occurrence of lead in certain foods, but the discovery of amounts sufficient to explain the entire lead excretion of our subject, except during the periods of lead administration, was entirely unexpected. Second, the daily intake of lead is exceedingly variable. Indeed so great is the variation that it is impossible to interpret the changes in the rate of lead excretion except as this factor is adequately controlled. The matter will be given fuller consideration later, but it must be stressed, here, that the observations of Aub and his associates, as well as of others, on the factors which influence the excretion of lead must be reviewed critically with this variable in mind. This is especially necessary since the general acceptance of their conclusions rests largely upon the uncertain evidence of the varying lead content of the faeces under various experimental conditions.

Another consideration of importance relates to the proportion of ingested lead which passes through the alimentary tract unabsorbed. Optimal conditions were present for the absorption of the administered lead, in that a dilute solution was taken at a time when there was the least opportunity for chemical reaction with the gastric contents. Yet slightly less than half the lead administered during the first period was absorbed, while more than two-thirds was eliminated unabsorbed during the second period. These observations furnish an explanation of the well recognized fact that heavy exposure for a short period of time is likely to be less injurious than a lighter exposure for a longer time. It may be calculated that if one milligram per day ~~were~~ had been taken for thirty days our subject would have absorbed not less than fifteen milligrams, while in six days at five milligrams a day he actually absorbed only nine milligrams. Thus if the same total quantities of lead ~~were~~ had been administered, the absolute quantity absorbed would ~~be~~ have been greater ~~when a~~ in the case of the small daily dosage ~~is~~ given over a longer period of time.

The sensitivity of the level of urinary excretion to the magnitude of absorption is also sharply indicated here. During the first period of administration, the subject apparently did not absorb more than half a milligram of lead per day. Yet the urinary excretion was measurably increased. However, in the subsequent period, the daily absorption was in excess of one milligram per day, and, though there was a definite rise in the urinary excretory rate, yet there ~~is~~ was no distinct increase in rate over that of the previous period. That is to say ~~that~~ the

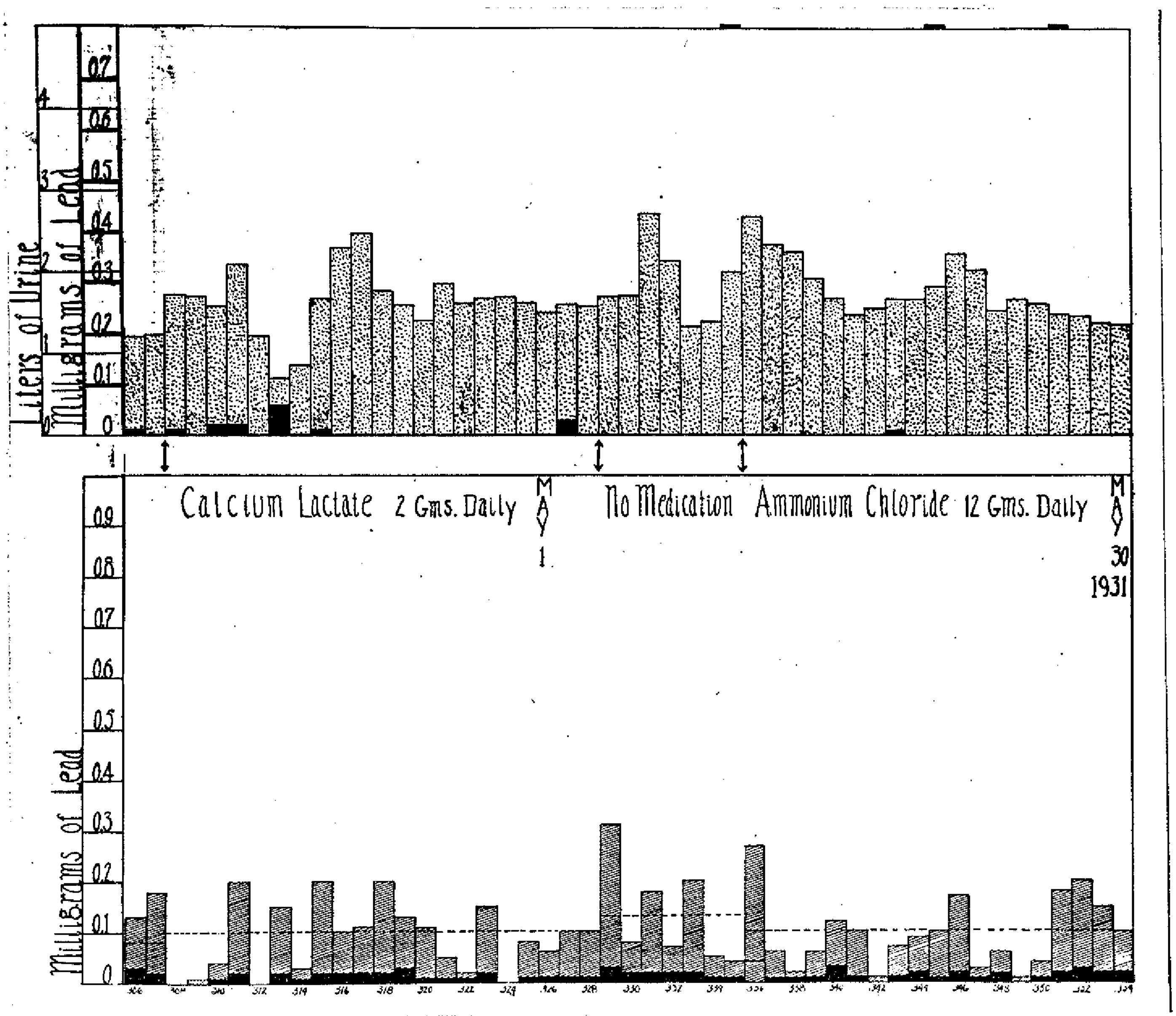

Fig. 7. Lead Excretion in a Normal Subject

The blocks represent consecutive daily observation as an uninterrupted continuation of Figures 1, 2, 3, 4, 5, 6.

excretory rate is not substantially altered by differences in absorption of this magnitude. Nevertheless the period of heightened lead excretion is prolonged under the influence of the increased absorption. This latter fact is especially significant when it is observed that the lead in the blood during the two periods is not changed within the limits of sensitivity of the method of observation. What obviously occurred was that the absorbed lead was so distributed in the tissues of the body as to increase their content without producing a corresponding degree of change in the concentration of lead in the blood, or the urine. Thus the period required for the elimination of the increased quantity in the tissues was prolonged.

In Figures 6 and 7 the observations on this subject were concluded, three hundred and fifty four days having elapsed during the study. The study of the lead in the food was discontinued as shown in Figure 6. Figure 7 shows a period of three weeks of increased calcium intake, and another similar period in which twelve grams of ammonium chloride were administered daily, with an intervening period of one week. Neither procedure resulted in any noticeable effect upon the excretory rate. It may be seen that the lead content of the food diminished considerably toward the end of our period of study. The maintained low level of faecal excretion suggests that the ingested lead remained low during the remainder of the study. Furthermore, the urinary excretion of lead was almost negligible during the period represented in these two figures. Tables VII and VIII show the frequency distribution of the results in milligrams per gram of ash in the faeces, and per liter of urine, together with the calculated means for these items. The percentage of negative
is larger than that which is shown in random samples of normal persons. Likewise
~~urinary results as well as~~ the mean value of lead per liter of urine,
is lower than the figure obtained from the study of numbers of normal subjects
is undoubtedly due in part to the fact that the urine was collected in twenty-four hour samples, the volumes of which in many instances were less than one liter. Such quantities obtained from normal subjects frequently

Table VII

Distribution of Urinary Samples ~~as~~ According to Lead in Milligrams per Liter

Milligrams of Lead Per Liter of Urine	Number	Percentage
0 - .009	179	57.9
.01 - .019	44	14.2
.02 - .029	33	10.7
.03 - .039	16	5.2
.04 - .049	15	4.9
.05 - .059	7	2.4
.06 - .069	5	1.6
.07 - .079	3	1.0
.08 - .089	1	.3
.09 - .099	2	.6
.10 - .109	1	.3
.11 - .119	2	.6
.22	1*	.3
Totals	309	100.

Mean = 0.0173 ± 0.001

S.D. = 0.0203

* Omitted in calculation of mean.

KE [illegible]

Table VIII

Distribution of Faecal Samples ~~as~~ according to Lead in Milligrams per Gram of Ash

Milligrams of Lead Per Gram of Ash	Number	Percentage
0 - .009	52	16.0
.01 - .019	95	29.2
.02 - .029	75	23.0
.03 - .039	38	11.7
.04 - .049	27	8.3
.05 - .059	20	6.1
.06 - .069	7	2.1
.07 - .079	3	.9
.08 - .089	2	.6
.09 - .099	3	.9
.10 - .109	2	.6
.11 - .119	1	.3
.13 -	1	.3
Totals	326	100.

Mean = 0.027 ± 0.0012

S.D. = 0.020

KE 0014194

fail to show amounts of lead which are capable of accurate quantitative estimation. For this reason not less than two liters is desirable for the purpose of each observation in a study of the normal excretion of lead. The conditions of the foregoing observations were devised with a full recognition that the limitations of the analytical methods would develop an increased importance in dealing with the samples of urine. This matter is of much less significance in the case of the faecal samples for thereason that the larger quantities of lead present reduce the proportional analytical error. ~~Therefore~~ the ~~comparatively low~~ value of the mean excretion of lead in milligrams per gram of ash is
also lower than the corresponding mean value shown by large groups of
~~evidence of a lower rate of lead excretion~~ than is ~~common in~~ normal subjects. (Cf. Tables XIII and XIV) The combined facts indicate that during the latter periods of the experiment, the subject had relatively little lead in his tissues, that he absorbed little from day to day, and that consequently he excreted very little.

The importance of the information presented in the foregoing figures is heightened by certain further considerations. Thus if the day-to-day variations in the lead content of the food are leveled by calculating the mean daily intake of lead, and if the daily excretion of lead in thefaeces and urine, exclusive of the periods of elevation occasioned by the experimental administration of lead, are calculated, the results are somewhat surprising. Tables IX, X and XI show respectively the frequency distributions of daily lead in food, urine, and faeces, with the calculated means, while Table XII compares daily ingestion and daily excretion. It is seen that the ingested lead is approximately equivalent to that which is excreted in the urine and faeces combined, the differences between their mean values being insignificant, statistically.

Table IX

Distribution of Daily Food Samples ~~as~~ according to Lead Content

Milligrams of Lead Found in 24 Hrs.	Number	Percentage
0 - .049	13	12.4
.05 - .099	15	14.3
.10 - .149	33	31.4
.15 - .199	24	22.8
.20 - .249	9	8.6
.25 - .299	5	4.8
.30 - .349	4	3.8
.35 - .399	0	
.40 - .449	0	
.45 - .499	2	1.9
Totals	105	100

Mean = 0.147 ± 0.006

S.D. 0.086

KE 0014486

Table X

Distribution of Twenty-Four Hour Samples of Urine according to Lead Content

Milligrams of Lead Found in 24 hrs.	Number	Percentage
0 - .019	172	55.7
.02 - .039	74	24.0
.04 - .059	30	9.7
.06 - .079	17	5.5
.08 - .099	8	2.6
.10 - .119	6	1.9
.12 - .139	1	0.3
.14 - .159	1	0.3
Totals	309	100

Mean 0.027 ± 0.001

S.D. ± 0.025

KE 0014487

Table XI

Distribution of Twenty-Four Hour Samples of Faeces according to Lead Content

Milligrams of Lead Found in 24 hrs.	Number	Percentage
0 - .049	46	14.1
.05 - .099	62	19.0
.10 - .149	79	24.2
.15 - .199	58	17.8
.20 - .249	33	10.2
.25 - .299	15	4.6
.30 - .349	18	5.5
.35 - .399	5	1.6
.40 - .449	2	.6
.45 - .499	4	1.2
.50 - .549	2	0.6
.78	1*	0.3
.82	1*	0.3
Totals	326	100

Mean = 0.151 ± .004

S.D. = 0.100

* These two aberrant results are not included in the calculation of the mean value.

KE 0014488

Table XII

Comparison of Mean Daily Lead Ingestion with Mean Daily Lead Excretion

Mean Daily Intake of Lead		0.147 ± .006
Mean Daily Excretion of Lead:		
In Urine	0.027 ± .001	
In Faeces	0.151 ± .004	0.178
Mean Daily Excretion of Lead (Arrived at by calculation from the actual data of combined urinary and faecal excretion from day to day.)		0.172 ± .004

KE 0014489

If the facts are examined in still another manner the same conclusions are evident. Thus if the periods of experimental administration of lead are eliminated, the subject excreted 48.95 mg. of lead in the faeces, and 6.00 mg. of lead in the urine, a total output of 54.95 mgs., in 329 days. During a period of approximately one third of this time (105 days) over which food analyses were made, he ingested approximately 15 mgs. of lead in his food.

It is difficult to escape the conclusion that substantially the entire lead interchange of the subject is to be explained by the occurrence of lead in his food. Certainly there can be no other factor of any important magnitude, though undoubtedly some small amount was contributed by drinking water and by other occasional contacts with lead. From this it follows that lead was not accumulating in the tissues except for short periods. Thus periods in which excretion exceeded intake alternated with periods in which excretion was less than intake, these effects being brought about by variations in activity, in water intake, in diet, - in short by a number of conditions well within the limits of normal physiological behavior.

[illegible] Hecker McS[illegible]

Urine

Faeces

Meals

KE 0014490

Table —

Distribution of Daily Food Samples of Four Subjects According to Lead Content

Milligrams of Lead per Daily Sample of Food	F.J.H.		Hock		McShane		Jones		Combined	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
0 – 0.049	13	12.4	17	15.0	13	11.5			43	13.0
0.05 – 0.099	15	14.3	29	25.7	23	20.3			67	20.3
0.10 – 0.149	33	31.4	23	20.3	21	18.6			77	23.3
0.15 – 0.199	24	22.8	14	12.4	17	15.0			55	16.6
0.20 – 0.249	7	6.6	12	10.6	17	15.0			38	11.5
0.25 – 0.299	5	4.8	6	5.3	7	6.2			18	5.4
0.30 – 0.349	4	3.8	1	0.9	5	4.4			10	3.0
0.35 – 0.399			2	1.8	2	1.8			4	1.2
0.40 – 0.449			1	0.9	2	1.8			3	0.9
0.45 – 0.499	2	1.9			2	1.8			4	1.2
0.50 – 0.549			4	3.5	2	1.8			6	1.8
.60			1	0.9					1	0.3
.70			1	0.9					1	0.3
1.17			1 *	0.9					1 *	0.3
1.34					1 *	0.9			1 *	0.3
1.36					1 *	0.9			1 *	0.3
1.64			1 *	0.9					1 *	0.3
Totals	105	100.0	113	100.0	113	100.0			331	100.0

Should be 127 each

	F.J.H.	Hock	McShane	Jones	Combined
Mean	0.147	0.155	0.168		0.157
Probable Error of Mean	± 0.006	± 0.008	± 0.007		± 0.004
Standard Deviation	± 0.[illegible]	± 0.132	± 0.113		± 0.113

Complete this table by the addition of data from Jones and the residue of
Hock subsequent to date finished at Ostende,
McShane " " " control period.

[illegible]

Hertzman

Lead in food for the 105 days period		14.80 mgs
Lead ingested		40 00 mgs
Total ingested		54 80 mgs
Lead in faeces for the period of 15 days	39.25	
Lead in Urine " " " " "	2.48	
		41.73
Total excreted		
Balance absorbed		13.07

3. Lead Excretion in Various Groups of Normal Subjects.

Prolonged daily observations on ~~a single~~ individual subjects yield information as to the variations in lead excretion attendant upon the changing circumstances in the life and activities of ~~a single~~ single individuals. A study of random samples of excreta from a large segment of the population might be expected to demonstrate a somewhat wider range of variability not only as the consequence of greater variation in environment and activity, but also because of differences in the physiological attributes of different individuals. Thus the investigation, of a large and representative group of persons who experience no occupational exposure to lead compounds, by the method of random sampling, should present a fairly adequate cross-sectional picture of the lead excretion of normal man under present conditions. Incidentally one may determine thereby, whether or not ~~the~~ any one individual ~~subject or any other~~ who has been studied in detail represents the average type of normal individual.

Several groups of subjects have been studied in the above manner. Medical students, with no previous occupational exposure to lead compounds, form the background for fixing the status of the one subject previously discussed. A number of persons selected from a much larger group of workmen because of their complete freedom from occupational lead exposure, constitutes an additional normal group. Still another group is made up of workmen with no lead exposure at the time of observations, but

KE 0014493

Table XIII

Distribution of Subjects According to Milligrams of Lead per Gram of Ash in the Faeces

Milligrams of Lead per Gram of Ash	Medical Students with No Lead Exposure at Any Time		Other Persons with No Lead Exposure at Any Time		Persons with Questionable or Slight Exposure in an Earlier Period	
	Number	Percentage	Number	Percentage	Number	Percentage
0 - 0.029	15	34.1	4	8.7	21	29.6
0.03 - 0.059	9	20.4	10	21.7	16	22.6
0.06 - 0.089	8	18.2	13	28.3	13	18.3
0.09 - 0.119	6	13.6	7	15.2	8	11.3
0.12 - 0.149	2	4.5	5	10.9	5	7.0
0.15 - 0.179			1	2.2	5	7.0
0.18 - 0.209	1	2.3				
0.21 - 0.239	1	2.3				
0.24 - 0.269			2	4.3		
0.27 - 0.299						
0.30 - 0.329					1	1.4
0.33 - 0.359			1	2.2		
0.36 - 0.389						
0.39 - 0.419	1	2.3	1	2.2	1	1.4
over 0.42	1*	2.3	2*	4.3	1*	1.4
Totals	44	100.00	46	100.00	71	100.00

Mean	0.069	0.098	0.072
Probable Error	±0.007	±0.008	±0.005
Standard Dev.	±0.071	±0.080	±0.068

Table ~~XIV~~

4

Distribution of Subjects According to Milligrams of Lead per Liter of Urine

milligrams of lead per liter of urine	Medical Students with No Lead Exposure at Any Time		Other Persons with No Lead Exposure at Any time		Persons with Questionable or Slight Exposure in an Earlier Period	
	Number	Percentage	Number	Percentage	Number	Percentage
0 - 0.029	9	20.4	7	15.9	8	11.3
0.03 - 0.059	14	31.8	11	25.0	24	33.8
0.06 - 0.089	9	20.4	11	25.0	22	31.0
0.09 - 0.119	8	18.2	5	11.4	6	8.5
0.12 - 0.149			3	6.8	2	2.8
0.15 - 0.179	1	2.3	1	2.3	3	4.2
0.18 - 0.209	1	2.3	3	6.8	2	2.8
0.21 - 0.239	1	2.3				
0.24 - 0.269						
0.27 - 0.299						
0.30 - 0.329	1*	2.3				
0.33 - 0.359						
0.36 - 0.389						
0.39 - 0.419						
0.42 -			3*	6.8	4*	5.6
Totals	44	100.00	44	100.0	71	100.00

	Medical Students	Other Persons	Persons with Questionable or Slight Exposure
Mean	0.067	0.076	0.069
Probable Error	±0.005	±0.005	±0.003
Standard Dev.	±0.047	±0.050	±0.041

*Excluded in calculation of mean

with an occupational history which did not permit of the certain exclusion of slight exposure at some previous time. The excretion of lead in the faeces and urines of these groups, and the calculated mean values for these factors, are presented in Tables XIII and XIV.

The three groups of subjects are so nearly identical as to be indistinguishable by any statistical means. On the other hand the medical student who was the subject of the prolonged study does not fit into any one of them, statistically, since there is a significant difference between his mean lead excretion and that of each of them. This causes ~~brings~~ us to recognize the importance of the somewhat limited diet of the subject in question. As a matter of choice and habit, this student ate somewhat sparingly, and introduced little variety into his choice of food, as a result ~~This~~ of which caused his lead intake was to be less than that of the average person. A further difference, affecting only the mean urinary excretion of lead, has been previously pointed out, in that the analytical error was somewhat enhanced by the smaller size of the urinary samples. It is clear, therefore, that although more detailed and specific information was obtained in the study of the one subject, a more accurate measure of general experience, as regards lead absorption and lead excretion, is to be found in the observations made on the larger number of subjects. Thus the mean lead excretion of normal persons in the United States, with no occupational exposure to lead compounds, is seen to be of the general magnitude of 0.07 milligrams per liter of urine, and 0.07 to 0.09 milligrams per gram ash of faeces. If the average urinary excrearded as approximately two liters per day, and if the l is expressed in terms of the mean daily output of a large number of normal individuals (see Table XVII), the average normal American excretes approximately rd of a milligram of lead per day.

ead as a Contaminant of Food and Drink.

he presence of lead in the normal food supply leads to a ~~requires~~ consideration of many possible sources for its origin. In to leave as little as possible to conjecture, large samples ngle common food materials ~~were~~ have been collected ~~over a three weeks~~ d in the course of ~~the observations~~ studies of the lead intake of various experimental subjects. on ~~the medical student~~ ~~ct detailed in Part 2~~. The results of ~~such~~ the analyses of such samples are ated in Tables XV, XVI, in which the actual weight of food examined, the actual amounts of lead found are given as a basis for the ulation of the concentrations of lead. The data are largely -explanatory, but certain matters merit further discussion.

(1) Lead is found in all ~~the~~ types of food materials studied, (without regard for) the variety or complexity of the processes of preparation and distribution.

(2) The quantity of lead in articles derived from grain and in most meats is quite small and would not be found detectable except for delicate methods of analysis carried out on large quantities of material. ~~The uniform occurrence of lead in grain products suggests its presence in growing vegetation. Obviously if such is the case, the presence of lead in meats is not remarkable.~~

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