

AGRICULTURAL EXPERIMENT STATION
Oregon State Agricultural College
Wm. A. Schoenfeld, Director
Corvallis

Circular of Information No. 193

December 1938

THE ASCORBIC ACID (VITAMIN C) METABOLISM OF COLLEGE STUDENTS

A Progress Report

of
Investigation of Vitamin C Requirements in Oregon Diets

by

Margaret L. Fincke
Associate Professor of Foods and Nutrition

The cooperative regional nutrition project of the Northwest States was carried on in the four states listed below and under the leadership of the following investigators during the college year, October, 1937 - June, 1938:

- Montana -- Agricultural Experiment Station:
Jessie Richardson assisted by Helen L. Mayfield
- Oregon -- State College and Agricultural Experiment Station:
Margaret L. Fincke assisted by Lillian H. Meyer
- Utah -- Agricultural Experiment Station:
Almeda Perry Brown assisted by Faye Moser
- Washington -- Agricultural Experiment Station:
E. Neige Todhunter assisted by Ruth C. Robbins
(Dr. Todhunter as chairman prepared this report)

Work on the project is being continued by the above investigators with Ella Woods of the Idaho Agricultural Experiment Station cooperating.

The accompanying data are presented as a progress report of work accomplished during the above period.

THE ASCORBIC ACID (VITAMIN C) METABOLISM OF COLLEGE STUDENTS

The necessity for a daily intake of ascorbic acid (vitamin C) is now well established but there is no agreement as to the amount required each day by individuals, nor as to the extent of vitamin C subnutrition of the population in various localities. Recently there have appeared in the literature reports of a number of studies designed to answer these questions but none of these is conclusive; also such reports have dealt mainly with children and hospitalized groups or with individual subjects.

At a meeting held in October, 1937, the nutrition research workers of the experiment stations of the Northwest States of Idaho, Montana, Oregon, Utah, and Washington agreed to cooperate in the study of the ascorbic acid metabolism of college students and took as their objectives (1) to find the most reliable method for determining the adequacy of ascorbic acid intake of students (2) to determine the state of ascorbic acid nutrition of college students (3) to find the relation of ascorbic acid nutrition to the dietary intake, and to physical factors such as age, sex, weight, and basal metabolism (4) to determine the actual requirement of college students for ascorbic acid and to make suitable recommendations in the light of this information.

For the year 1937 - 1938, the group undertook the investigation of the existing state of ascorbic acid nutrition of college women students by determining the level of urinary excretion of ascorbic acid while the students were eating their customary diets and when they were given a single massive dose of 600 mg. of ascorbic acid. This work was carried on at the agricultural experiment stations of Montana, Oregon, Utah, and Washington, with Idaho beginning experimental work in the fall of 1938.

This paper presents the method of procedure and the data obtained in the first year of the investigation.

Experimental Procedure

As far as possible, freshman women students were used as subjects because it was believed that they would be more likely to reflect the home background of vitamin C intake than older students who had been subjected to college dormitory life for some time or who had received through their class work some education as to food values.

Students were interviewed at the beginning of the study and were asked to keep a dietary record of all food eaten for the week prior to beginning the urinary collections and for the three days of the urine collections. As much information as possible was obtained from the student with regard to her age, height, weight, type of activity, time of menstrual period, use of aspirin, bicarbonate of soda and similar drugs. A sample record sheet is included in Table VI showing the type of information obtained at the beginning and the end of the study.

Basal metabolism was measured in those laboratories where time and circumstances permitted.

Collection of urine

Twenty-four-hour urinary samples were obtained for three-day periods (with a few exceptions) from each subject. The morning of beginning the test the subject was instructed to empty the bladder on rising and to collect all urine for the remainder of that day and also the first excretion the following morning; this constituted the first twenty-four-hour sample. The second day's collection was begun immediately and included the first excretion the following morning and this was repeated the third day.

Urine was collected in one quart mason jars with wide mouth tops and containing an acid preservative solution; these jars were kept in covered boxes or dark cloth bags so that light was excluded, but during the twenty-four-hour collection period the urine samples remained at room temperature in the residence of the student. Each twenty-four-hour sample was taken to the laboratory early in the morning and the titration usually was carried out soon after the sample was received.

A preservative solution was placed in each jar before collections were begun so that the urine was at all times in an acid medium and air was excluded by a layer of toluene. The preservative used was recommended by Dr. Julius Sendroy, Jr. (personal communication) and was as follows:

In each jar was placed 75 c.c. of 5 N sulphuric acid, 1 c.c. of 8 hydroxy-quinoline (1.45 gm. hydroxy-quinoline in 100 c.c. of alcohol) and 5 c.c. of toluene. If necessary before titration the pH of the urine plus preservative was adjusted so that it was not above pH 3. The volume of urine was measured and whenever possible a sample immediately before or after the collection period was obtained without preservative and the specific gravity measured.

Method of determining ascorbic acid content of urine

The ascorbic acid content of the urine was determined by titration with 2,6 dichlorophenolindophenol, using dye tablets of Hoffmann-La Roche.¹ Each tablet was dissolved in warm water which had been redistilled from glass, and made up to a volume of 50 c.c. after cooling. Any insoluble residue was allowed to settle and the clear solution pipetted off into a 10 c.c. burette of narrow bore with subdivisions of 1/20 c.c. The dye tablets were frequently standardized against pure l-ascorbic acid.²

1.

Acknowledgment is made to Hoffmann La Roche for a generous supply of dye tablets to each of the laboratories cooperating in the investigation.

2.

Acknowledgment is made to Merck and Company for a generous supply of Cebione to each of the laboratories cooperating in this investigation.

Measured volumes of urine were placed in 125 c.c. Erlenmeyer flasks, a sufficient volume of urine being taken so that from 2 to 5 c.c. of dye solution were required to reach the endpoint which was a pink color lasting 30 second.³

The total titration was finished in less than 2 minutes. Determinations were made in triplicate and a burette lamp was used in order to standardize light conditions as far as possible.

"Saturation" tests

Following a three day period of urinary collection and determination of the so called resting level of ascorbic acid excretion, a single massive dose of 600 mg. of ascorbic acid (Cebione. Merck and Co.²) was given before eight o'clock in the morning and the following twenty-four-hour excretion of urine was collected in the same manner as previously described. The amount of reducing substance present in the twenty-four-hour excretion following the massive dose was calculated as ascorbic acid and was expressed as the percentage of the 600 mg. test dose.

Results and Discussion

In conducting this investigation certain difficulties were encountered which must be considered in evaluating the data. First, the question as to whether urinary samples were complete twenty four-hour samples should be considered. The Oregon investigators felt that some of the freshman subjects failed to realize the importance of accuracy on this point, and also the fact that college buildings were far apart on the campus and the student living quarters sometimes one-half mile to a mile from the campus, made collections difficult. For this reason, the freshman data which appeared to be in any way questionable were omitted and the remainder of the study was devoted to sophomores and upper classmen. The Utah investigators also felt that freshman students were unappreciative of the necessity for completeness in collection of twenty-four-hour samples of urine and they, therefore, included a number of older students in their study. The investigators of the Montana and Washington stations felt that there was no reason to question the completeness of the samples obtained from the freshmen groups which they studied.

All investigators realized that too much reliance could not be placed on the dietary information. Students probably did not always record everything eaten nor did they always correctly estimate the amount eaten. However, it is believed that the dietary records have some value as an indication of the general eating habits of the students and do show the frequency of consumption of certain types of foods.

The color of the urine in some samples interfered with detection of the end point.

3.

A 10 second end point has been agreed upon for all future work.

It is recognized that titration with 2,6-dichlorophenolindophenol does measure some reducing substances other than ascorbic acid and that in urine samples with a low reducing value the error from this cause is proportionately higher.

The data obtained are presented here in detail in the accompanying tables and graphs but it is not proposed to discuss these results at length nor to draw any conclusions because it is believed that work now in progress may aid in the interpretation of some of the findings the meaning of which is not entirely clear at the time of presenting this progress report.

Urine preservative

The value of the acid preservative was checked in several laboratories by taking fresh urine and determining the ascorbic acid content, and then adding the preservative and allowing to stand at room temperature for twenty-four hours then again measuring the ascorbic acid content. Oregon investigators found an average recovery of 95 per cent in 11 determinations, the range being 78 to 106 per cent. Utah investigators obtained a 71 per cent recovery after twenty-four hours for a sample of urine and a 97.6 per cent recovery for an ascorbic acid solution held at room temperature for twenty-four hours. In the Washington State College laboratory, the recovery after twenty-four hours averaged 98 per cent for 5 determinations ranging from 95.4 to 101.1 per cent.

Resting level of excretion

The level of excretion of the four groups of college students while on their customary or self-chosen diets is presented in Tables I (a), I (b), and Tables II (a), II (b), and Figures I (a), I (b). A wide range in the excretion level is seen in all groups, but there was least variation in the Washington group where all students were freshmen and were eating in dormitories (with the exception of three who lived in sorority houses) where the meals were under the supervision of a dietitian. The Montana group also showed a comparatively small range with the exception of two students, number 17 with the low value of 2.7 mg. and number 7 with the high value of 163.0 mg.; the dietary records as summarized in Table V (a) offer no explanation of these extremes.

From Table IV, it is seen that the majority of subjects from all colleges excreted 15 mg. or more; a level slightly above that of 13 mg. which has been suggested by Harris⁴ as representing a so-called "minimum standard" level of excretion; of the total of 170 measurements of urinary excretion of these subjects 24 or 7 per cent of the group were below the 15 mg. level.

It is of interest to note that in the Utah group when other students as well as freshmen were studied, the average daily output of ascorbic acid increased with the years in college. Nine freshmen had an average excretion of 21.7 mg., three sophomores excreted 47.7 mg., two juniors 51.1 mg., ten seniors 96.6 mg. and six graduates 112.8 mg. Whether or not this relation would hold for a large number of subjects in each group is an interest-

ing conjecture. Since the subjects reported above were all students of nutrition it would appear that their training is effective insofar as dietary ascorbic acid is involved.

Oregon State subjects were also from different college years and some faculty members were included. There was little difference in the first three-year groups; twenty-four freshmen had an average excretion of 32.3 mg., twenty-two sophomores 28.3 mg., and eleven juniors 37.6 mg.; the senior group is really too small for comparison, there being only three with an average of 42.9 mg. The five graduate students averaged 69.2 mg. and five faculty members 145.3 mg.; this would at least indicate that a greater knowledge of the importance of vitamin C requirement was reflected in the dietary intake and consequently in the urinary output also.

"Saturation" tests

Many factors may influence the so-called resting level of excretion, and also there is no evidence that a given level of excretion indicates that the organism is receiving adequate supplies of vitamin C. The general assumption of investigators in this field has been that if the individual organism is "saturated", the administering of a large single dose of ascorbic acid will be followed by a marked rise in the excretion of ascorbic acid within the next twenty-four hours. There has been no agreement among research workers as to the size of the dose to be used for such a test: doses ranging from 100 to 1,000 mg., have been used. It has been shown however that the larger the test dose the proportionately smaller is the return of that test dose. The 600 mg. test dose has been recommended by Youmans⁵ who suggests that an excretion of 30 per cent of such a test dose is the lower limit of "saturation".

Our data in Table I (a), I (b), III and Figures II (a), II (b), II (c) show a wide variation in response to the test dose and no evidence of a close relation between resting level of excretion and response to the test dose.

It is possible that the test dose used in these studies was too large to give any indication of the state of saturation of the subject and for future work by this group of investigators a smaller test dose of 300 mg. is being used.

It seems clear that there is a wide individual response to the test dose and that a certain resting level of excretion may be coexistent with saturation in one subject and not in another.

4.

Harris, L. J., Abbasy, M. A., Yudkin, J. and Kelly, S. Vitamins in human nutrition. Lancet 1. 1488. 1936

5.

Youmans, J. B., Corlette, M. B., Akeroyd, J. H., Frank, H. Studies of vitamin C excretion and saturation. Am. Jour. Med. Sci. 191. 319. 1936

Evaluation of dietary records

The dietary records which were kept by the students prior to, and during the period of urine collections were evaluated by checking the number of servings of vitamin C-containing foods and dividing by the number of days for which records were kept, thus giving the average number of servings per day. Since different foods vary in ascorbic acid content, the following grouping was agreed upon for evaluating the diet sheets: (1) citrous fruits, tomatoes, raw cabbage, strawberries raw or canned (2) uncooked fruits and vegetables, canned fruits, potatoes (3) other cooked vegetables (4) milk. The results from the diet sheets of the different colleges which were evaluated in this manner are summarized in Table V (a), V (b), V (c), V (d).

Summary

Tables of data and graphs showing the excretion of ascorbic acid of college women while on their customary diets and following a single massive dose of 600 mg. of ascorbic acid are presented. This work is a progress report of an investigation of the ascorbic acid metabolism of college women being carried on cooperatively by investigators at the Agricultural Experiment Stations of Montana, Oregon, Utah, and Washington

TABLE I (a) MONTANA SUBJECTS

ASCORBIC ACID EXCRETION OF SUBJECTS ON CUSTOMARY DIETS
AND FOLLOWING A 600 MG. TEST DOSE

Sub- ject No.	Class	Boarding place	Av. Volume	Av. Ascorbic	Volume	Ascorbic	Per cent return of test dose %
			urine excreted (3 days) c.c.	acid excreted daily (3 days) mg.	urine after test dose c.c.	acid after test dose mg.	
1	Fresh.	Coop.	993	21.0	1836	379.1	63.2
2	Fresh.	Coop.	1063	29.1	1454	539.9	90.0
3	Fresh.	Coop.	546	12.3	557	234.9	39.1
4	Fresh.	Coop.	992	19.9	1684	302.7	50.4
5	Fresh.	Dorm.	584	33.2	547	217.5	36.2
6	Fresh.	Dorm.	715	35.7	1349	238.3	39.7
7	Fresh.	Dorm.	1542	163.0	1771	710.4	118.4
8	Fresh.	Dorm.	747	25.0	1189	529.0	88.2
9	Fresh.	Dorm.	341	23.0	697	451.0	75.2
10	Fresh.	Dorm.	612	31.4	929	179.0	29.8
11	Fresh.	Dorm.	532	22.2	737	415.6	69.3
12	Fresh.	Dorm.	1061	20.7	1304	605.9	101.0
13	Fresh.	Dorm.	942	19.5	1279	282.2	47.0
14	Fresh.	Dorm.	680	30.5	969	555.0	92.5
15	Fresh.	Dorm.	269	10.4	367	107.5	17.9
16	Fresh.	Dorm.	679	19.2	929	545.7	90.9
17	Fresh.	Dorm.	655	2.7	682	8.7	1.4
18	Fresh.	Dorm.	1336	22.1	953	449.3	74.9

TABLE I (b) UTAH SUBJECTS

ASCORBIC ACID EXCRETION OF SUBJECTS ON CUSTOMARY DIETS AND FOLLOWING A
600 MG. TEST DOSE; ALSO BASAL METABOLISM

Sub- ject	Class	Boarding place	Av. volume urine excreted (3 days) c.c.	Volume urine after test dose c.c.	Specific gravity	Av. ascorbic acid excreted daily (3 days) mg.	Ascorbic acid excreted after test dose mg.	Per cent return of test dose %	Basal metabolism cal. per sq. m. per hour
1	Senior	Board. H.	1224	1275	1.014	41.5	446.4	74.40	57
2	Senior	Bach. Apt.	1090	1554	1.018	11.6	381.5	63.6	54
3	Senior	Bach. Apt.	788	1380	1.018	13.4	56.1	9.3	48
4	Fresh.	Board. H.	752	610	1.031	33.3	249.8	41.6	53
5	Fresh.	Dorm.*	462	900	1.020	4.6	247.5	41.2	51
6	Fresh.	Board. H.	586	620	1.027	9.0	406.7	67.8	--
7	Fresh.	Board. H.	925	875	1.023	11.4	311.5	51.9	50
8	Fresh.	Bach. Apt.	918	350	1.010	16.7	232.4	38.7	55
9	Fresh.	Board. H.	1094	1554	1.009	27.3	494.2	82.4	62
10	Senior	Board. H.	660	985	1.026	112.4	630.4	105.1	48
11	Soph.	Home	932	875	1.015	26.2	432.2	72.0	49
12	Grad.	Home	880	1050	1.019	101.4	548.1	91.3	56
13	Junior	Dorm.*	1160	1125	1.026	20.5	427.5	71.2	56
14	Grad.	Home	859	1110	1.019	46.7	477.3	79.5	56
15	Grad.	Bach. Apt.	928	755	1.034	23.6	336.7	56.1	31
16	Grad.	Home	1568	1310	1.020	280.1	605.2	100.9	52
17	Senior	Board. H.	484	700	1.026	13.1	271.6	45.3	53
18	Junior	Home	601	935	1.026	87.8	445.1	74.2	52
19	Grad.	Home	965	825	1.020	148.8	488.4	81.4	54
20#	Sr.Man.	Home	1820	1660	1.024	199.9	365.2	60.9	--
1	Senior	Board. H.	1417	1275	1.025	69.8	408.0	68.0	57
2	Senior	Bach. Apt.	1105	1525	1.012	76.9	349.2	58.2	54
23	Senior	Bach. Apt.	905	1175	1.028	390.0	674.4	112.4	--
24	Soph.	Home	1821	2885	1.025	108.8	516.4	86.1	53
16	Grad.	Home	1462	1090	1.019	76.4	559.2	93.2	52
17	Senior	Board. H.	1045	735	1.027	37.2	505.7	84.3	53
27	Fresh.	Bach. Apt.	857	--	1.027	39.6	--	--	63
28	Fresh.	Board. H.	719	--	1.030	42.9	--	--	61
29	Fresh.	Board. H.	890	--	1.018	10.4	--	--	55
30	Soph.	Bach. Apt.	461	--	1.030	8.4	--	--	53

* Building temporarily rented by college, managed by faculty member

This subject asked to be studied because of interest in the project

TABLE II (a) OREGON SUBJECTS

ASCORBIC ACID EXCRETION OF OREGON STUDENTS
WHILE ON CUSTOMARY DIETS

Subject Number	Class	Boarding place	Av. volume urine excreted (3 days)	Av. ascorbic acid excreted daily (3 days)
			c.c.	mg.
1	F.	Coop.	1227	118.7
2	F.	Sorority	447	12.7
3	F.	Dorm.	818	43.3
4	F.	Room	878	56.3
5	F.	Dorm.	1210	24.1
6	F.	Dorm.	728	24.2
7	F.	Dorm.	982	18.3
8	F.	Dorm.	460	10.5
9	F.	Sorority	465	13.8*
10	F.	Dorm.	940	15.2*
11	F.	Dorm.	1025	17.9
12	F.	Dorm.	643	11.8
13	F.	Dorm.	660	14.3
14	F.	Home	1160	103.4*
15	F.	Room	735	10.2*
16	F.	Dorm.	1032	20.2
17	F.	Dorm.	743	54.0
18	F.	Sorority	843	70.8
19	F.	Coop.	787	12.6
20	F.	Dorm.	878	21.7
21	F.	Coop.	1435	32.6
22	F.	Room	793	16.2
23	F.	Dorm.	743	29.3
24	So.	Dorm.	435	10.8#
25	So.	Dorm.	573	12.0
26	So.	Dorm.	828	48.8
27	So.	Dorm.	1355	21.2
28	So.	Home	798	60.5
29	So.	Dorm.	1837	22.8
30	So.	Home	1073	28.5
31	So.	Dorm.	780	14.9
32	J.	Dorm.	1548	35.3
33	So.	Sorority	668	41.9*
34	So.	Sorority	1002	49.1
35	J.	Dorm.	920	21.4*
36	So.	Dorm.	917	26.8
37	?	Dorm.	2000	87.2
38	So.	Sorority	505	13.5*
39	So.	Sorority	537	25.3
40	So.	Sorority	1317	32.3
41	F.	Sorority	525	23.2*
42	Se.	Dorm.	1232	58.0

(continued)

TABLE II (a) OREGON SUBJECTS (continued)
 ASCORBIC ACID EXCRETION OF OREGON STUDENTS
 WHILE ON CUSTOMARY DIETS

Subject Number	Class	Boarding place	Av. volume urine excreted (3 days)	Av. ascorbic acid excreted daily (3 days)
			c. c.	mg.
43	So.	Dorm.	755	26.9
44	So.	Sorority	867	21.1
45	J.	Sorority	942	12.9
46	So.	Sorority	735	22.2*
47	So.	Dorm.	1177	70.4
48	So.	Dorm.	1128	18.4
49	So.	Dorm.	773	27.0
50	So.	Sorority	960	15.3*
51	So.	Sorority	662	13.2
52	J.	Dorm.	1103	18.3
53	J.	Dorm.	1060	124.0#
54	Se.	Sorority	1035	42.3
55	Se.	Home	740	28.4
56	J.	Sorority	1042	26.9
57	J.	Home	1165	74.7
58	J.	Sorority	1258	50.8
59	J.	Dorm.	1062	17.3
60	J.	Sorority	1060	13.9
61	G.	Home	1782	133.9
62	J.	Coop.	1878	18.2

* Average of two days only

One day only

TABLE II (b) WASHINGTON SUBJECTS

ASCORBIC ACID EXCRETION OF WASHINGTON STUDENTS
WHILE ON CUSTOMARY DIETS

Subject Number	Class	Boarding place	Av. volume	Av. ascorbic acid
			urine excreted (3 days)	excreted daily (3 days)
			c.c.	mg.
1	Senior	Sorority	745	15.2
2	Senior	Dorm.	1093	16.9
3	Senior	Dorm.	1366	34.2
4	Freshman	Dorm.	623	52.4
5	Freshman	Dorm.	1180	24.2#
6	Freshman	Dorm.	1098	24.6
7	Freshman	Dorm.	1267	19.5
8	Freshman	Dorm.	980	25.6
9	Freshman	Dorm.	1383	28.5
10	Freshman	Dorm.	1095	26.4
11	Freshman	Dorm.	1333	18.0
12	Freshman	Dorm.	1733	27.1
13	Freshman	Dorm.	1413	15.8
14	Freshman	Dorm.	1647	20.7
15	Freshman	Dorm.	992	18.9
16	Freshman	Dorm.	693	17.7
17	Freshman	Dorm.	1260	17.2*
18	Freshman	Dorm.	1297	20.5
19	Freshman	Dorm.	1100	20.9
20	Freshman	Dorm.	1280	61.6
21	Freshman	Dorm.	1458	21.2
22	Freshman	Dorm.	1145	37.8*
23	Freshman	Dorm.	1162	29.9
24	Freshman	Dorm.	2475	37.5
25	Freshman	Dorm.	1852	44.1
26	Freshman	Sorority	662	20.5
27	Freshman	Dorm.	1093	23.3
28	Soph.	Dorm.	720	24.3
29	Freshman	Dorm.	1817	17.7
30	Freshman	Dorm.	1448	18.9*
31	Freshman	Dorm.	1182	16.8
32	Freshman	Dorm.	838	15.5
33	Freshman	Dorm.	1140	38.7
34	Freshman	Sorority	607	19.0
35	Freshman	Dorm.	1728	65.0
36	Freshman	Dorm.	1353	27.6
37	Soph.	Dorm.	1900	26.5
38	Freshman	Dorm.	1043	32.6*
39	Freshman	Dorm.	1590	37.1
40	Freshman	Dorm.	1503	20.1
41	Freshman	Dorm.	447	14.0
42	Freshman	Dorm.	1506	55.6*

* Average of 2 days

Average of 4 days

TABLE III

EXCRETION OF ASCORBIC ACID FOLLOWING A TEST DOSE OF 600 MG.,
BY STUDENTS OF OREGON, AND WASHINGTON STATE COLLEGES

Sub- ject Num- ber	Class	Boarding place	Av. volume urine, resting level (3 days) c.c.	Volume urine after test dose c.c.	Av. ascorbic acid excreted daily (3 days) mg.	Ascorbic acid excreted after test dose mg.	Per cent return of test dose %
<u>Oregon State Subjects</u>							
*63	Faculty	Home	1425	1850	72.9	608.0	101.3
*64	Faculty	Home	1650	3885	117.2	348.9	58.1
*65	Faculty	Home	1575	1660	84.4	217.6	36.3
*66	Faculty	Home	5655	4720	135.3	445.5	74.2
63	Faculty	Home	1475	1590	112.7	305.3	50.9
64	Faculty	Home	1925	2040	204.8	398.4	66.4
65	Faculty	Home	1335	1390	94.2	308.6	51.4
67	Grad.	Home	2390	2198	27.0	304.6	50.8
68	Grad.	Room	1918	1760	27.2	257.2	42.9
69	Faculty	Room	1130	2000	84.9	506.2	84.4
70	Faculty	Room	2315	2790	229.7	468.7	78.1
71	Grad.	Home	1658	1580	70.8	389.3	64.9
72	Grad.	Practice House	1795	2080	86.9	314.5	52.4
<u>Washington State Subjects</u>							
10	Fresh.	Dorm.	1150	1140	21.8	146.8	24.5
11	Fresh.	Dorm.	1470	1210	23.9	109.2	18.2
12	Fresh.	Dorm.	2080	1010	30.6	359.9	60.0
16	Fresh.	Dorm.	360	670	24.8	164.2	27.4
20	Fresh.	Dorm.	1113	1020	41.4	352.6	58.8
39	Fresh.	Dorm.	1590	1110	37.1	420.1	70.0
40	Fresh.	Dorm.	1503	1420	20.1	459.1	76.5
41	Fresh.	Dorm.	447	490	14.0	334.9	55.8
42	Fresh.	Dorm	1560	1240	55.6	246.7	41.1

* 600 mg. dose of ascorbic acid was supplied as orange juice.

TABLE IV

NUMBER OF SUBJECTS EXCRETING ASCORBIC ACID
AT VARIOUS LEVELS

Range of excretion of ascorbic acid mg.	Number and percent of group excreting at each level							
	Montana		Oregon		Utah		Washington	
		%		%		%		%
Below 15	3	16.7	14	18.7	8	26.7	1	2.1
15 - 30	10	55.3	29	38.7	5	16.7	33	70.2
30 - 45	4	22.2	6	8.0	5	16.7	9	19.1
45 - 60			6	8.0	1	3.3	3	6.4
60 - 100			11	14.7	4	13.3	1	2.1
100 - 200	1	5.5	7	9.3	5	16.7		
Over 200			2	2.6	2	6.7		
Total ascorbic acid measurements on subjects	18		75*		30*		47*	

* In each of these groups two separate determinations were made on 4 subjects of Oregon and of Utah group and on 5 Washington subjects.

TABLE V (a) MONTANA SUBJECTS

AVERAGE DAILY INTAKE OF CERTAIN FOOD SOURCES
OF ASCORBIC ACID BY DIFFERENT SUBJECTS

Av. number of servings per day

Subject Number	Boarding Place	Citrus fruits tomatoes raw cabbage strawberries raw or canned	Canned fruits raw fruits or vegetables potatoes	Other cooked vegetables	Milk
1	Coop.	1.0	1.5	0.8	2.4
2	Coop.	1.3	1.1	0.6	2.4
3	Coop.	0.5	1.9	0.6	0.0
4	Coop.	0.8	1.5	1.2	1.6
5	Dorm.	0.6	2.7	1.1	1.0
6	Dorm.	0.8	2.9	1.0	1.0
7	Dorm.	1.7	2.9	1.1	1.2
8	Dorm.	0.7	3.0	1.1	0.7
9	Dorm.	1.3	1.7	1.1	1.5
10	Dorm.	1.2	2.5	0.8	1.4
11	Dorm.	1.4	2.0	1.4	0.6
12	Dorm.	0.7	1.8	1.6	0.0
13	Dorm.	1.0	2.3	1.6	0.7
14	Dorm.	0.6	3.7	1.0	1.2
17	Dorm.	0.6	3.0	0.8	0.8
18	Dorm.	0.8	3.0	1.0	0.3

TABLE V (b) OREGON SUBJECTS

AVERAGE DAILY INTAKE OF CERTAIN FOOD SOURCES
OF ASCORBIC ACID BY DIFFERENT SUBJECTS

Av. number of servings per day					
Subject Number	Boarding Place	Citrus fruits, tomatoes, raw cabbage, strawberries raw or canned	Canned fruits, raw fruits or vegetables, potatoes	Other cooked vegetables	Milk
1	Dorm.	2.7	5.0	1.9	0.0
2	Sorority	1.4	1.4	1.2	0.8
3	Dorm.	1.6	2.3	1.0	0.0
4	Room	1.3	1.8	2.0	1.2
5	Dorm.	0.7	2.4	1.1	0.0
6	Dorm.	0.3	1.1	1.0	0.6
7	Dorm.	1.0	1.7	1.8	1.7
8	Dorm.	0.4	2.2	1.1	1.7
9	Sorority	0.3	1.5	1.8	0.3
10	Dorm.	0.2	1.8	2.8	0.8
11	Dorm.	0.5	2.3	1.7	0.7
12	Dorm.	0.5	1.6	0.9	0.4
13	Dorm.	0.4	3.1	1.1	1.3
14	Home	2.1	2.0	0.5	1.2
15	Room	0.3	2.3	2.9	0.0
16	Dorm.	0.9	1.9	1.6	1.1
17	Dorm.	1.5	2.5	0.9	0.5
18	Sorority	1.4	1.4	1.9	0.9
19	Dorm.	0.3	2.2	1.3	0.0
20	Dorm.	0.4	2.0	2.4	0.7
21	Dorm.	0.5	4.8	1.5	0.5
22	Room	0.4	2.3	0.9	0.0
23	Dorm.	0.8	2.4	1.0	0.1
24	Dorm.	0.7	1.7	1.7	3.7
25	Dorm.	0.9	2.2	1.9	0.8
26	Dorm.	1.0	2.8	2.0	3.1
27	Dorm.	0.7	2.1	1.6	1.6
28	Home	0.7	1.0	1.1	2.6
29	Dorm.	2.2	2.3	2.2	2.2
30	Home	0.5	2.3	1.3	1.3
31	Dorm.	1.0	2.0	1.5	1.2
32	Dorm.	1.3	2.3	1.6	1.5
33	Sorority	1.9	2.1	1.1	1.6
34	Sorority	1.7	2.3	0.7	1.7
35	Dorm.	1.2	1.4	1.4	1.8
36	Dorm.	0.7	2.4	1.2	0.0

(continued)

TABLE V (b) OREGON SUBJECTS (continued)

AVERAGE DAILY INTAKE OF CERTAIN FOOD SOURCES
OF ASCORBIC ACID BY DIFFERENT SUBJECTS

Av. number of servings per day					
Subject Number	Boarding Place	Citrus fruits tomatoes, raw cabbage, strawberries raw or canned	Canned fruits, raw fruits or vegetables, potatoes	Other cooked vegetables	Milk
37	No Record				
38	Sorority	0.7	1.6	0.9	0.7
39	Sorority	1.0	1.7	1.7	0.9
40	Sorority	0.2	1.3	1.6	0.6
41	Sorority	0.6	1.2	1.5	0.2
42	Dorm.	0.6	3.0	1.3	1.3
43	Dorm.	0.7	2.6	1.3	1.1
44	Sorority	0.8	1.7	1.5	0.5
45	No Record				
46	Sorority	0.9	2.0	1.6	0.0
47	Dorm.	1.1	2.4	2.8	2.4
48	Dorm.	0.7	1.4	1.9	0.0
49	Dorm.	1.5	2.0	1.8	1.7
50	Sorority	0.8	1.4	1.6	0.8
51	Sorority	0.8	1.2	1.0	0.0
52	Dorm.	0.8	1.9	1.6	0.5
53	Dorm.	1.2	1.1	1.4	0.4
54	Sorority	1.3	2.1	0.9	1.5
55	Home	0.4	2.6	1.7	0.0
56	Sorority	0.4	1.9	1.9	0.0
57	Home	1.5	1.6	1.8	0.5
58	Sorority	1.2	2.2	1.3	0.2
59	Dorm.	0.4	2.8	1.7	0.7
60	Sorority	0.5	2.7	1.7	1.0
61	Home	2.4	1.7	1.7	1.5
62	Dorm.	0.7	2.4	1.6	0.7

TABLE V (d) WASHINGTON SUBJECTS

AVERAGE DAILY INTAKE OF CERTAIN FOOD SOURCES
OF ASCORBIC ACID BY DIFFERENT SUBJECTS

Subject Number	Boarding Place	Av. number of servings per day				Number of days food recorded
		Citrus fruits, tomatoes, raw cabbage strawberries, raw or canned	Canned fruits, raw fruits or vegetables, potatoes	Other cooked vegetables	Milk	
1	Sorority	0.25	2.1	1.2	0.5	8
2	Dorm.	1.0	2.3	0.9	0.5	11
3	Dorm.	0.6	2.8	1.0	1.4	8
4	Dorm.	1.4	2.3	1.2	0.0	9
5	Dorm.	0.7	2.3	1.3	2.3	15
6	Dorm.	0.7	1.7	1.4	1.2	9
7	Dorm.	0.6	2.6	1.2	0.1	9
8	Dorm.	0.0	3.2	1.4	1.3	10
9	Dorm.	0.5	3.7	0.6	0.1	10
10	Dorm.	0.3	2.7	1.7	4.0	3
11	Dorm.	0.7	2.1	1.5	1.5	13
12	Dorm.	0.5	2.2	1.3	2.2	13
13	Dorm.	0.8	2.2	1.4	2.9	10
14	Dorm.	0.3	3.6	1.1	2.0	7
15	Dorm.	0.5	3.1	1.4	2.3	10
16	Dorm.	0.4	1.8	0.9	0.5	10
17	Dorm.	0.5	2.7	1.3	1.7	10
18	Dorm.	0.5	3.0	1.4	2.9	9
19	Dorm.	0.4	3.4	1.9	2.3	9
20	Dorm.	1.4	2.6	1.2	0.0	13
21	Dorm.	0.3	2.6	1.4	0.0	10
22	Dorm.	0.9	2.8	1.3	2.2	10
23	Dorm.	0.5	2.5	1.2	2.1	8
24	Dorm.	0.2	2.5	1.5	1.8	10
25	Dorm.	0.6	2.9	1.1	3.5	10
26	Sorority	0.5	2.6	1.4	1.4	10
27	Dorm.	0.6	2.1	1.1	0.2	8
28	Dorm.	0.5	1.7	1.1	0.1	11
29	Dorm.	0.5	2.6	1.3	0.3	10
30	Dorm.	0.8	2.4	1.7	1.1	10
31	Dorm.	0.6	2.3	1.2	1.6	10
32	Dorm.	0.4	2.2	1.4	1.4	5
33	Dorm.	0.3	2.6	1.4	1.1	10
34	Sorority	0.5	2.6	0.9	0.7	10
35	Dorm.	1.7	1.6	1.0	0.0	10
36	Dorm.	0.9	3.0	0.8	1.8	10
37	Dorm.	0.8	2.8	1.1	5.0	11
38	Dorm.	0.6	0.7	1.1	0.0	10
39	Dorm.	0.7	3.2	0.7	2.2	4
40	Dorm.	0.4	3.2	1.4	2.6	5
41	Dorm.	1.2	1.8	0.3	2.0	6
42	Dorm.	0.5	3.0	0.5	1.5	4

TABLE V (c) UTAH SUBJECTS

AVERAGE DAILY INTAKE OF CERTAIN FOOD SOURCES
OF ASCORBIC ACID BY DIFFERENT SUBJECTS

Subject Number	Boarding Place	Av. number of servings per day			
		Citrus fruits, tomatoes, raw cabbage, strawberries raw or canned	Canned fruits, raw fruits or vegetables, potatoes	Other cooked vegetables	Milk
1	Boarding H.	1.4	1.4	0.9	1.0
2	Bach. apt.	1.1	1.6	0.7	1.7
3	Bach. apt.	0.5	2.5	0.9	0.9
4	Boarding h.	1.4	1.6	1.2	1.5
5	Dormitory*	0.3	2.1	0.6	0.4
6	Boarding h.	1.8	1.4	0.8	1.4
7	Boarding h.	0.7	2.6	1.1	0.6
8	Bach. apt.	0.4	1.7	0.9	1.7
9	Boarding h.	1.6	1.7	0.1	0.6
10	Boarding h.	2.2	2.6	0.9	0.1
11	Home	0.9	1.8	2.1	2.2
12	Home	1.1	1.9	1.3	1.9
13	Dormitory*	1.2	1.5	1.0	0.8
14	Home	1.0	1.9	1.0	1.0
15	Bach. apt.	1.0	1.2	1.3	1.4
16	Home	2.9	1.2	0.5	0.5
17	Boarding h.	1.2	2.0	1.3	0.6
18	Home	1.4	1.9	0.5	1.0
19	Home	1.7	2.5	0.6	0.2
20	Home	2.5	4.0	1.2	1.2
1	Boarding h.	1.7	1.6	0.8	1.5
2	Bach. apt.	1.7	1.8	0.6	1.6
23	Bach. apt.	2.4	1.1	1.3	1.0
24	Home	1.4	2.9	1.2	0.0
16	Home	1.8	0.4	1.4	0.8
17	Boarding h.	1.0	1.4	0.7	0.3
27	Bach. apt.	1.6	1.6	1.0	0.4
28	Boarding h.	1.1	1.8	0.5	0.2
29	Boarding h.	0.9	1.5	0.8	0.1
30	Bach. apt	0.8	1.7	0.9	0.0

* Building temporarily rented by college, managed by a faculty member

TABLE VI. RECORD SHEET

SUBJECT _____ COLLEGE YEAR _____ DATE _____

Local residence _____ Home: rural or urban _____

Age _____ Height _____ Weight _____

Menstrual period (last day) _____ or length period _____

Exercise _____

Perspiration _____ Games _____ Nervousness _____

Previous illness _____

Drugs taken: aspirin _____ soda _____ iodine _____
 iron salts _____ thyroxin _____ others _____

Physical exam: heart rate _____ respiration _____
 hemoglobin _____ chest _____ heart _____ B.M. _____
 other _____

DIET: estimated vitamin C per day _____ No. days diet recorded _____

URINE: Normal

Date	Volume	Ascorbic acid mg/per c.c.	Average ascorbic acid excretion/day	Remarks

Saturation Test: Amount ascorbic acid given: _____

Date	Volume	Ascorbic acid mg/c.c.	Remarks

NOTES: _____

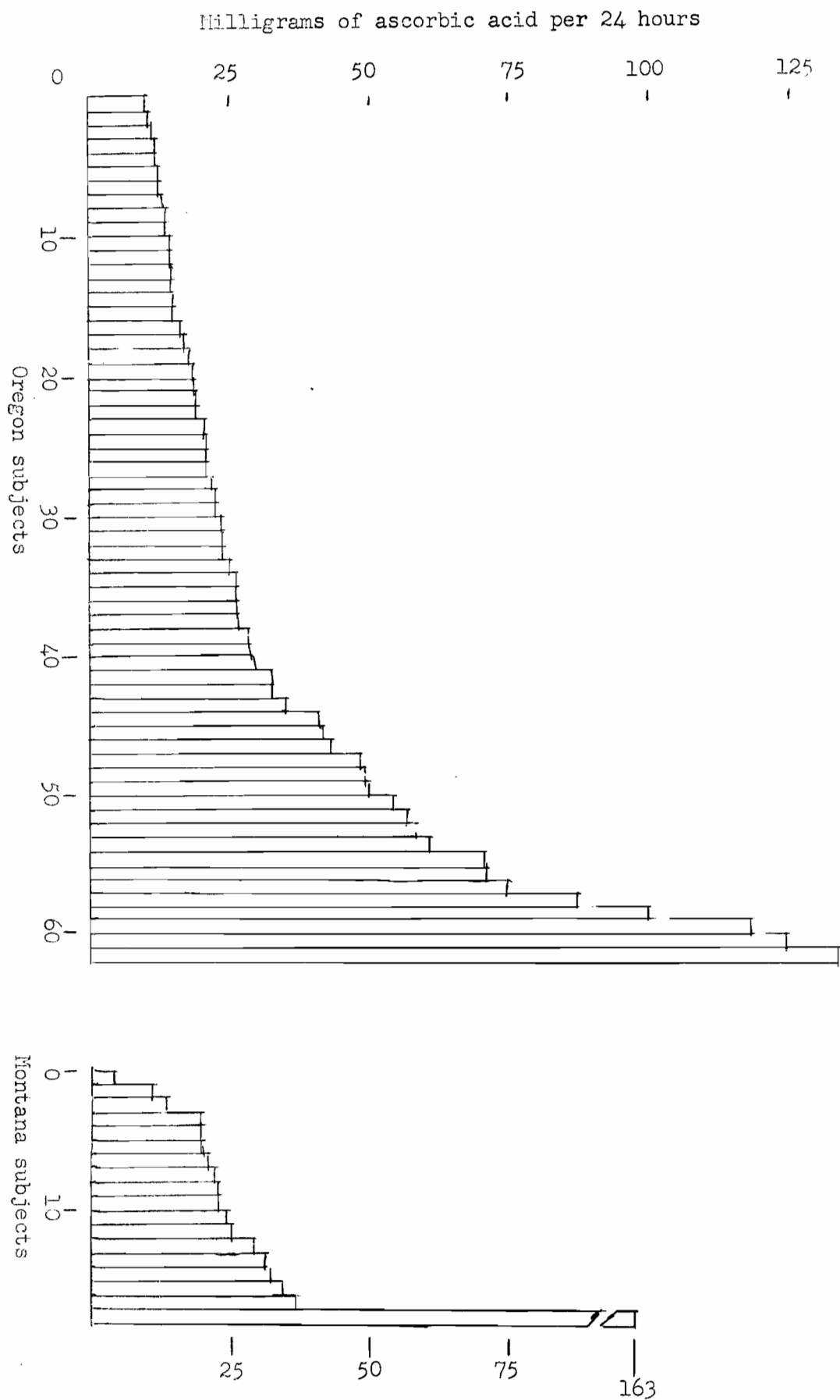


Fig. I. (a) Levels of excretion of ascorbic acid by individual subjects of Oregon and Montana; each block represents one subject.

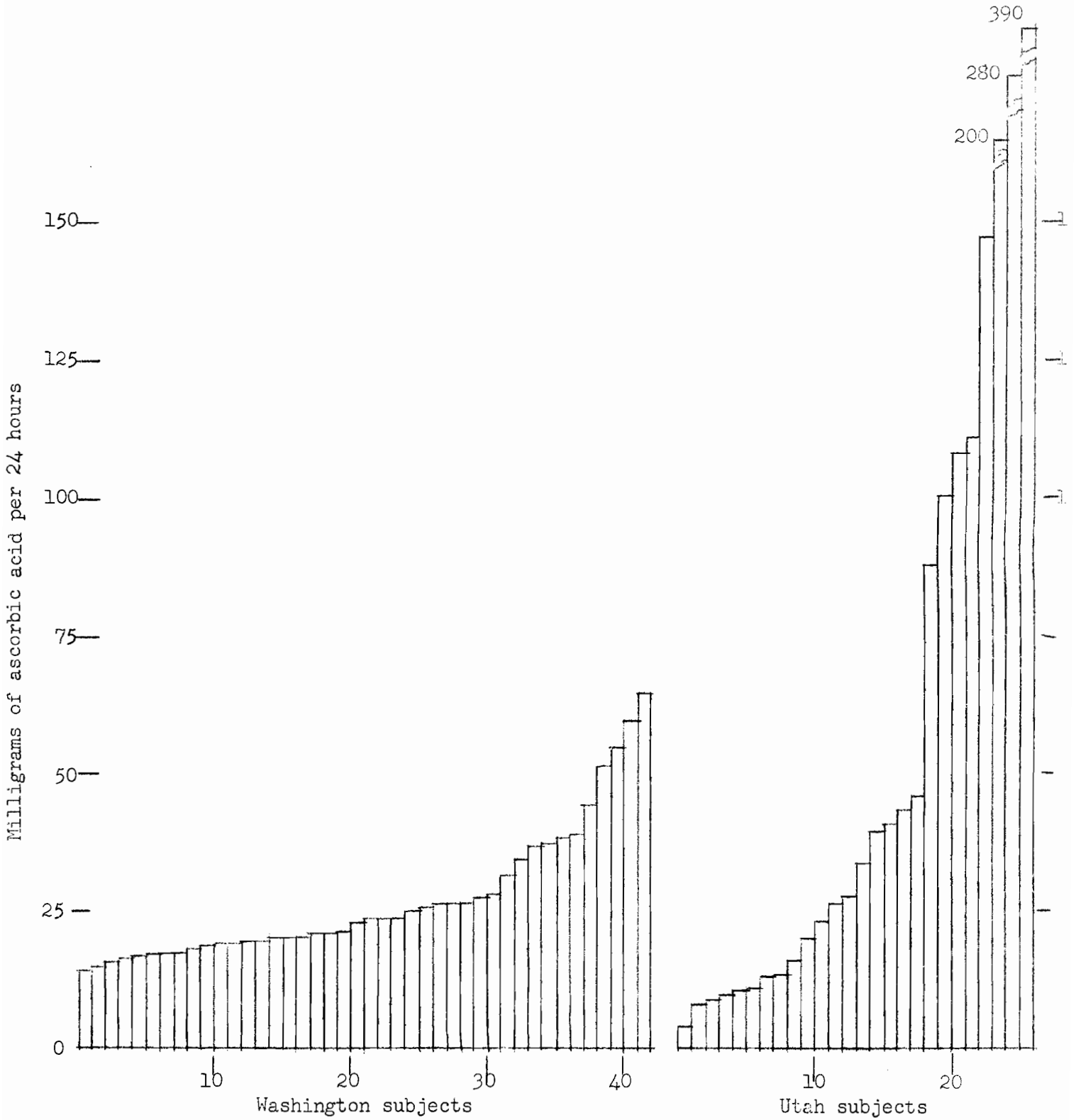


Figure 1 (b). Levels of excretion of ascorbic acid by individual subjects of Washington and Utah; each block represents one individual.

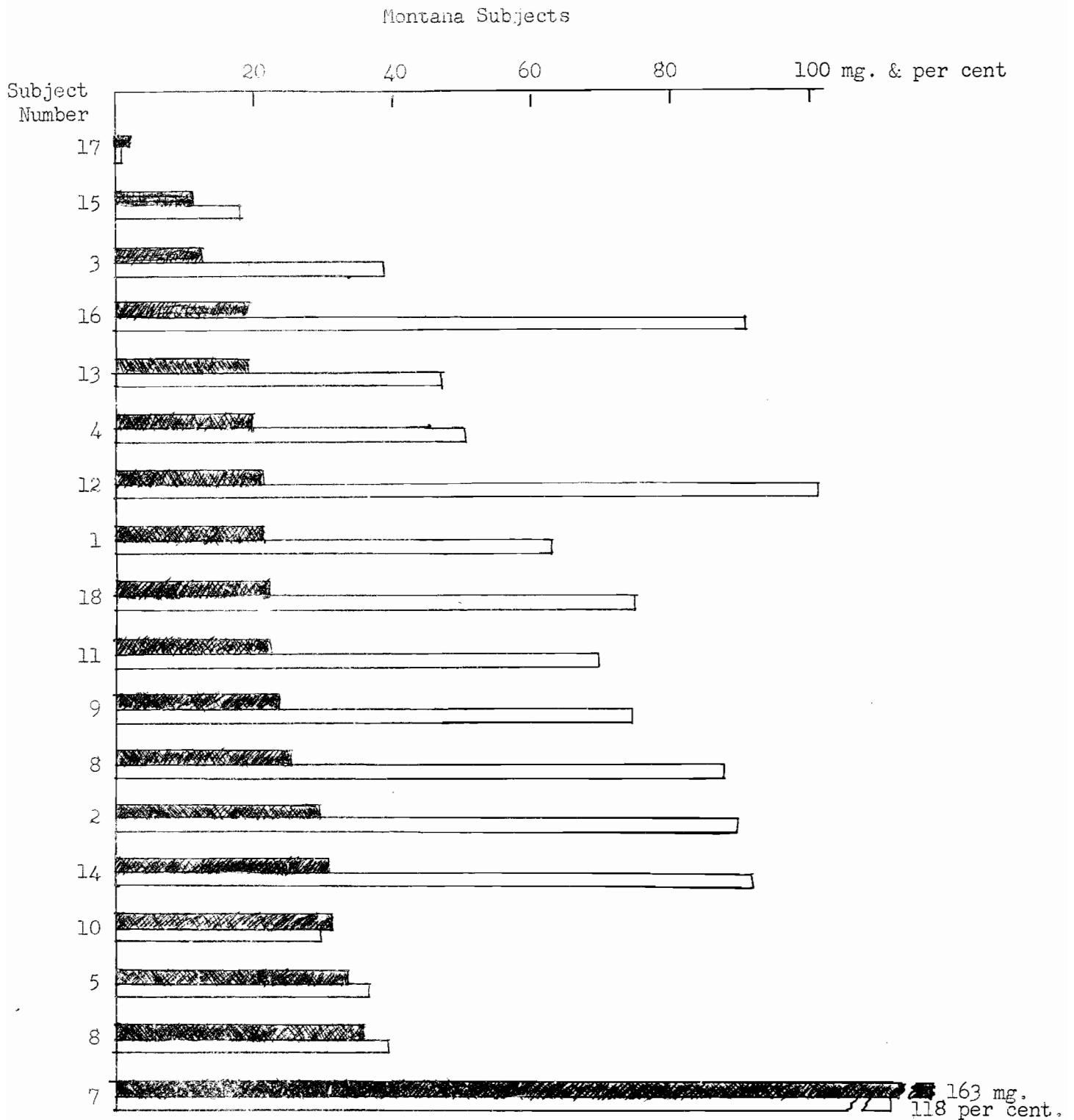


Fig. 2 (a) Comparison of "resting" level of excretion of ascorbic acid and percent return of 600 mg. test dose by Montana subjects. mg. ascorbic acid resting level; percent return of test dose.

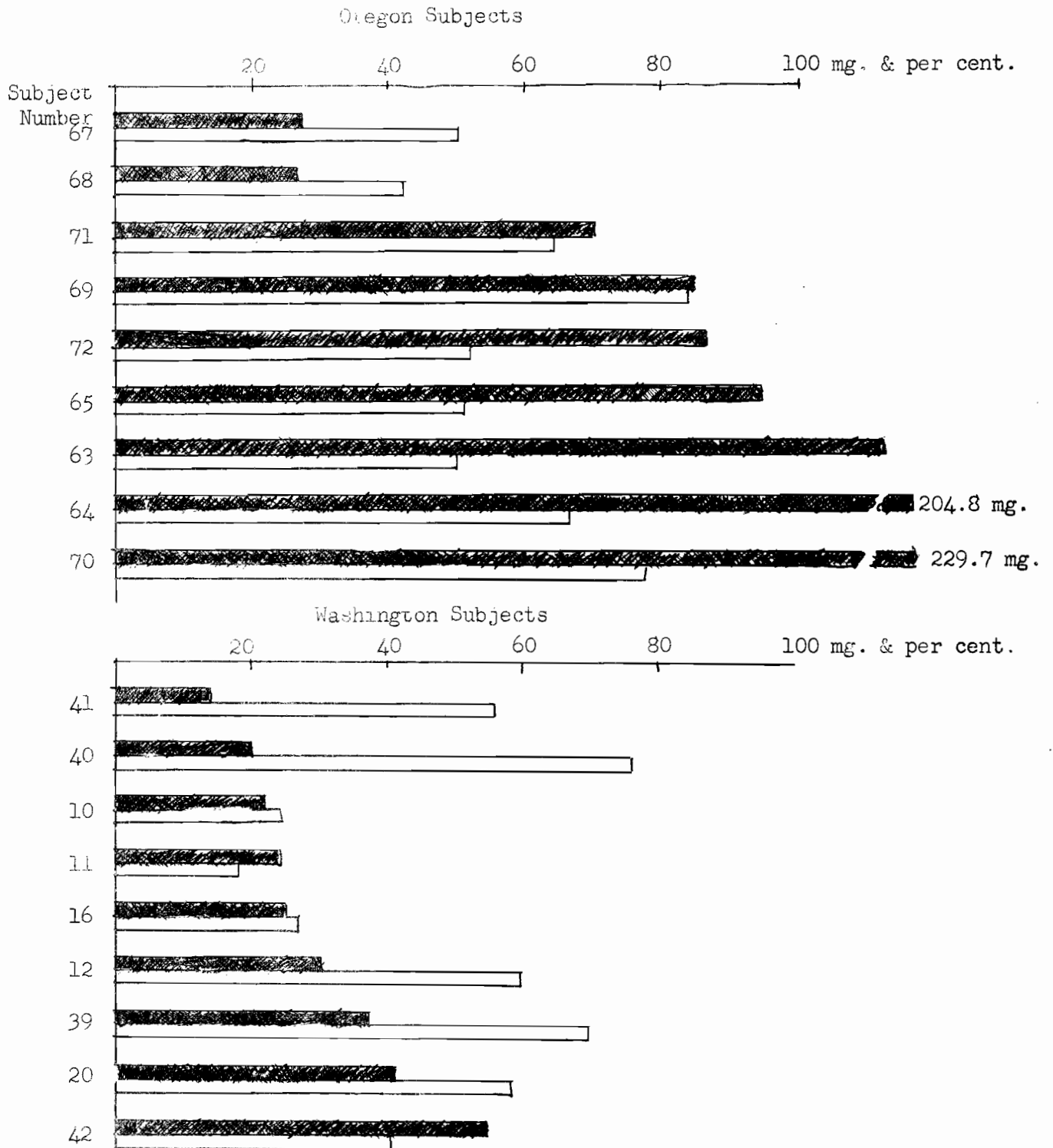


Fig. 2 (b) Comparison of "resting" level of excretion of ascorbic acid and percent return of 600 mg. test dose by Oregon and Washington subjects. mg. ascorbic acid "resting" level; percent return of test dose.

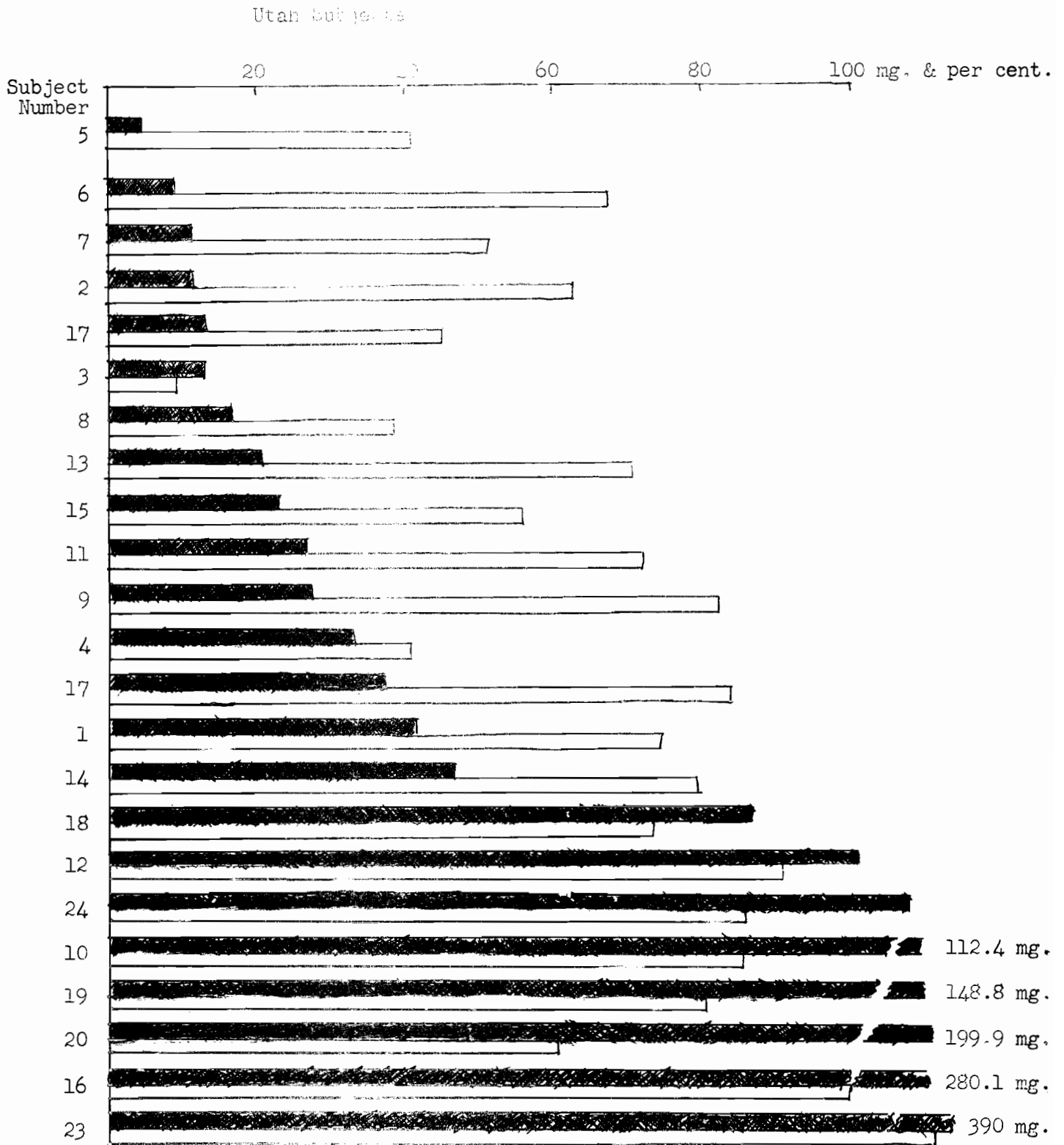


Fig. 2 (c) Comparison of "resting" level of excretion of ascorbic acid and percent return of 600 mg. test dose by Utah subjects. ████████ mg. ascorbic acid resting level; percent return of test dose.