"Clinical Nutritional Study
of
Minimum Protein and Caloric Requirements
for Man"

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by

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Preface

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I INTRODUCTION AND BACKGROUND

The feeding of man in space poses several unique problems. For space flights of any duration, the problems of food dispensing and limitations of weight and volume will restrict the amount and type of provisions. Some of these problems are mainly in the field of food technology and should be solved quite readily. However, the nutrient properties of this diet command much greater attention.

Although for flight of short duration, nutrients beyond water, salt, and calories are assumed to be relatively unimportant, as longer missions are contemplated and attempted the problem of nutrient requirements becomes of increasing importance. This is particularly true since the foods will probably be from limited sources, increasing possibilities of introducing deficiencies. Even minor deficiencies must be avoided since the performance of the astronauts must be kept at an absolute peak. As the requirements for nutrients will probably no longer be met by stored foods but through regenerative food systems, and since many of these systems will probably provide food both qualitatively and quantitatively in unusual forms, the range of adaptability of man to various nutrient sources, his ability to cope with relatively large concentrations of "unusual food sources," and mainly a definition of the "minimal but adequate" nutritional requirements of man must be carefully evaluated.

By "adequate but minimal" nutrition we mean nutritional status that will maintain biochemical, physiological, and psychological functions: that is, maintain without impairment the total performance capacity of the individual. Although no one can predict which nutrient may serve as the "limiting variable" in this overall definition, two of the most important variables to be considered in establishing the "minimum but adequate" diet are protein and energy requirements. The initial studies reported here consider the problem of protein. The purpose of the present series of studies was to determine, at adequate energy intake, the minimal dietary level of high-quality protein needed to maintain total nitrogen balance, normal health, and functional capability. The primary technique used is that of determination of external metabolic balances, but the studies are unique in that all routes of nitrogen loss from the body are measured: gaseous and solid wastes from the intestinal tract, urinary, and integumentary losses. In addition to this, studies of physiological performance, psychological integrity, and social integration were also undertaken.

II SUMMARY AND CONCLUSIONS

Three studies are covered in this report. Study #1 was a 60-day study of 4 subjects. Two of the subjects served as controls throughout the test period, receiving about 75 g of egg albumin protein and about 3200 Kcal daily. Two subjects were given a protein-free diet during one 15-day metabolic period and the control protein level during all other periods. This Study was used to determine the magnitude of endogenous nitrogen loss under our test conditions.

Study #2 was conducted with 6 subjects for 88 days. Two of the subjects who participated in the first study were volunteer subjects in the second study. Again, two subjects served as controls throughout the test, consuming about 75 g of protein per day. The remaining 4 subjects were placed on the same protein and caloric intake during standardization and recovery periods; however variables of (a) endogenous nitrogen loss and zero protein intake and (b) nitrogen balance during administration of protein at the determined minimum endogenous level were studied.

Study #3 was a 44-day study in which 12 subjects occupied the metabolic facility and were housed 4 in a room. This Study was designed to test the comparative nutritional properties of the Gemini diet and the control formula diet used for experimental studies within the Department of Nutritional Sciences. Six of the subjects received 75 g of protein contained in the formula during the entire period; the other 6 received the Gemini diet. However, the caloric intake was decreased by about 500 Kcal per day for all subjects in Study #3 as compared to Studies 1 and 2.

The subjects were all adult male volunteers ranging in age from 20 to 39 years. Most of them were or had been students at the University of California or at other colleges in the area immediately preceeding the period of study. The volunteer subjects were allowed to participate in the studies after psychological testing, interview by staff members, a thorough history, physical examination, and extensive laboratory screening revealed no significant deviation from normal. Approximately 1 out of 4 volunteers was selected.

All studies were carried out in the Human Nutrition Research Laboratory, which is a fully equipped, 7-room metabolic unit occupying the top floor of Agnes Fay Morgan Hall, the main building housing the Department of Nutritional Sciences; and analytical work was carried out in other laboratories of the Department.

In addition, in Studies 2 and 3 members of the Space Sciences Laboratory, Social Science Division, conducted a study of group behaviour.

The diets which have been developed specifically for these studies are formula-type and were developed to fulfill criteria of (a) nutritional adequacy and (b) ability of experimenters to manipulate the diets without knowledge of changes in protein composition or content on the part of the experimental subjects. Criteria of protein adequacy measured were: external balances of nitrogen; balances of potassium and phosphorus (since loss of these minerals from the healthy body when intake is adequate generally signifies destruction of protein or lean body tissue) and to interpret these data further balances of calcium, magnesium, sodium, and chloride; body composition by several methods; formed elements of blood; blood proteins; lipid constituents; transaminase activity; loss of constituents from the integument; rate of growth of facial hair and fingernails; salivary protein; nitrogen and sperm content of semen; losses due to breakdown of dietary constituents in flatus and transfer of this material across the alveolar membrane and loss in expired respiratory gas; physical capacity by ventilatory and cardiac response to graded levels of work on bicycle ergometer; cardiovascular responsiveness by an adjustment to tilt; complex reaction time by simulated driving test; computational facility; visual function by dark adaptation, critical frequency of fusion of flicker, and loss of hue of high-intensity monochromatic light; highly stressed memory capacity; and personality and mood by a variety of standard instruments.

During the course of the experiment the activity was kept relatively constant through a scheduled program of treadmill work in an attempt to maintain constant fitness and to prevent either deterioration or gain in muscle strength or mass.

The results summarized here are those considered by the principal investigators to be most significant.

A. Nitrogen Balance and Excretion

It was found that the minimum endogenous nitrogen loss corrected for any apparent errors for usual underestimation of loss was approximately 3.25 g on a caloric intake of about 3200 Kcal per day. This endogenous level was achieved after about 6 to 8 days of a protein-free diet after which there was little significant further decline or adaptation over the total 15 or 18 days of observation. When an attempt was made to maintain nitrogen balance by supplying protein at this level, protein balance was not achieved although the degree of negativity was quite small (about 200-500 mg/day).

It appears therefore that utilizing a high-quality protein with adequate calories at the endogenous level is not quite adequate to maintain nitrogen equilibrium. In Study #3 it was noted that most subjects, both on the Gemini and the formula diet, were in negative nitrogen balance during the entire period of observation. The reason for this is not clear; variables which have been considered are (a) a lower intake of calories than those observed in Studies 1 and 2 and (b) decreased physical activity both as a result of decrease in prescribed activity and decreased activity due to the crowding of the physical plant or (c) the stress of crowding intensifying hormonal or physiological factors leading to increased protein breakdown. These hypotheses will be tested in subsequent experiments.

B. Other Nitrogen Losses

All subjects receiving the formula diet showed a progressive decrease in urinary creatinine during the entire period of study. This change in creatinine excretion was independent of alterations in protein intake. The reason for this change is not clear and will be investigated further. However, the finding is significant and may indicate an inadequacy of the formula-type diet.

The mean loss of nitrogen from the integument of the subjects receiving the control diet was approximately 1 percent of the nitrogen intake, the losses ranging from 90 to 200 mg/day. When the nitrogen intake was reduced to zero or 3+ g/day, there was a definite decrease in the amount of nitrogen lost through the skin and sweat which amounted to as much as a 35 percent decrease when compared with the control period of the subject. This decrease correlated well with decrease in blood urea nitrogen noted during the periods of zero and low protein intake. During the low and zero nitrogen protein intake, the rate of hair growth remained the same as did the percentage of nitrogen in the integumentary appendages.

C. Weight Changes

The studies of body composition were quite disappointing. They showed that in our hands the correlations between various methods of measuring as well as replicate measurements utilizing the same technique were not very high. The variation was so great as to make interpretation of balance data and small body weight changes utilizing body composition techniques valueless. Therefore, for interpretation of smaller changes in body weight we must continue to rely on theoretical weight calculations from balance data.

D. Blood Chemistry

Few blood constituents showed any change due to dietary protein manipulations. There was no consistent change in serum proteins, either total or various fractions studied by electrophoresis. The only significant changes noted were a marked decrease in blood urea nitrogen during periods of zero protein intake to values as low as 5 or 6 mg/100 ml., with only a slight rise during the periods of low protein intake. Another interesting observation on subjects on the formula diet (but unrelated to protein level) was a significant fall in serum cholesterol levels of all subjects with initial levels over 140 mg/100 ml. There was no significant change in triglyceride level.

E. Excretion of Electrolytes

One of the most significant findings was the marked changes in urinary calcium noted with alterations in protein intake. It was seen that at zero protein level there was a marked decrease in urinary calcium with intermediate levels being achieved at the 3 g nitrogen intake. A similar fall, but of lesser magnitude, was noted in the case of urinary magnesium. The reason for these changes is not clear at this time. The remaining mineral excretion balance and excretion patterns were as expected. There was an increased loss of potassium and phosphorus during the periods of zero protein intake that corresponds to the negative nitrogen balance and breakdown of protein tissue to be expected during this experimental manipulation.

F. Other Effects

There was no demonstrable alteration or deterioration of physiological, psychomotor, or sensory performance noted as a result of dietary manipulation. The extensive psycho-social observations as well as socio-legal observations are summarized in the body of the report. Extensive critical analyses of possible dietary variables on these factors have not yet been examined; but there appears to be no evidence for dietary effects on these complex functions during the periods of observation in our experiments.

III EXPERIMENTAL PLAN

This report covers 3 sets of experiments conducted during the years 1964 and 1965. These studies have been designated as "Penthouse" studies and assigned numbers in order of their performance. Hence, these studies are designated Penthouse Studies 1, 2, and 3. In the presentation of data each subject is identified by 4 numbers. The first 2 numbers identify the study number and the second 2 the subject's number; thus, "0104" would be Study #1, subject 4.

Study #1 was a 60-day study divided into 4 major 15-day metabolic periods, each of 3 minor periods of 3-, 6-, and 6-day duration. The purpose of this study was (a) to perform a "total" nitrogen balance study on man on an adequate protein diet and (b) to determine the total endogenous nitrogen losses on as close to zero protein intake as possible. In the "zero" protein diet, protein was removed, carbohydrate substituted for protein to maintain calories constant, and all other dietary constituents unchanged.

Study #2 was an 88-day study divided into 5 major metabolic periods (the first of 12-day duration and the remainder of 18-day duration), each of 3 minor periods of 6-day duration, and was a continuation of Penthouse Study #1. The total balance on an adequate protein diet and the minimum endogenous losses on a protein-free diet were determined and an attempt was made to maintain nitrogen equilibrium in subjects when they were given dietary protein at the level of the minimum endogenous loss.

Study #3 was utilized to obtain further control data to increase the observations of Studies 1 and 2. This was a 6-week study, divided into 6-day metabolic periods. In addition, this study was designed to test nutritional adequacy of the Gemini diet.

The general overall plans of Studies 1, 2, and 3 are shown in Table 1. It should be noted that 2 subjects served as controls for the duration of Studies 1 and 2.

EXPERIMENTAL PROTOCOL*

STUDY #1:

Subject	Period 1	2	3	4
0101	C	C	O	CR
0102	C	C	C	CR
0103	C	C	O	CR
0104	C	C	C	CR

STUDY #2:

Subject	Period 1	2	3	4	5
0201	C	C	C	C	C
0202	C	C	C	C	C
0203	C	O	L	L	CR
0103- 0204	C	L	R	O	CR
0104- 0205	C	O	L	L	CR
0206	C	O	R	L	CR

STUDY #3:

Subject	Entire Study
0301	G
0302	C
0303	G
0304	G
0305	G
0306	C
0307	C
0308	G
0309	C
0310	C
0311	C
0312	G

* C = control diet (12+ g N)
O = protein-free diet (0.6 g N)
L - low protein diet (3+ g N)
R = recovery diet (12+ g N)
G = Gemini diet (16+ gN)

IV SELECTION OF SUBJECTS

The subjects were selected from a large group of volunteers. The screening and selection was performed in a step-wise fashion, the individuals first filling out a personality inventory, followed by an interview to evaluate motivation and personality and to obtain a brief history. From these a small number were selected and given a thorough medical examination and extensive laboratory screening; attempts were also made to select subjects with considerable variation in age, body build, and race, as shown in Table 2.* Two of the volunteers who had been involved in Study #1 returned to participate in Study #2. Most of the subjects were attending college or university just prior to the experiment, and in Study #3 one was a participant-observer. His purpose in volunteering was to obtain social-psychological data which could not be obtained by other staff via constant observation, and his dual role was known to all subjects.

The subjects were housed in the Human Research Laboratory of the Department of Nutritional Sciences. They remained confined for the entire duration of each experiment except for two occasions during the course of Study #2 when they left as a group under the observation of a member of the staff, once for recreational purposes and the other time to maintain activity constant when a treadmill broke down. This confinement within the experimental unit allowed for close observation of the subjects as well as programming of activity.

In an attempt to obtain "total" nitrogen balance, all losses were measured. Excreta were collected during the entire period for determination of nutrient balances. Integumentary losses were ascertained under "average" conditions of work and environmental temperatures as were losses that might be observed under maximum physical exertion with sweating. In Study #1 semen and saliva were examined. Relevant biochemical measurements were made on blood and urine at periodic intervals. Physiological performance was assessed regularly as nutritional variables were introduced.

During the third study, food attitude questionnaires were introduced; and the attitudes toward the diet and the experimental milieu were determined. The Space Sciences Laboratory of the University of California at Berkeley used the

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*Physical data on all subjects will be found in Appendix I;
Psychological data for subjects in Study #3 will be found in Appendix II.

Table 2

AGE, WEIGHT, HEIGHT, AND RACE OF SUBJECTS

Subject	Age	Weight (kg)	Height (cm)	Race
0101	37	67.7	188	Caucasian
0102	25	62.5	173.5	Caucasian
0103	23	63.8	179.5	Caucasian
0104	21	80.3	184.5	Caucasian
0201	26	70.9	188	Caucasian
0202	24	76.5	170	Caucasian
0203	27	68.9	185	Caucasian
0204	24	65.4	179.5	Caucasian
0205	21	79.7	184.5	Caucasian
0206	28	59.1	173	Caucasian
0301	20	56.5	165	Oriental
0302	21	79.6	172	Caucasian
0303	30	89.3	182.5	Negro
0304	21	79.7	184.5	Caucasian
0305	20	69.3	173	Caucasian
0306	21	83.7	182	Caucasian
0307	21	68.0	176.5	Caucasian
0308	23	76.2	181	Caucasian
0309	22	80.3	181.5	Caucasian
0310	29	67.5	180	Caucasian
0311	39	88.9	184	Caucasian
0312	29	71.4	178.5	Caucasian

opportunities provided by experiments 2 and 3 to study independently some aspects of the sociological, political, and legal behavior of confined groups; these studies have been reported in detail in "The Legal Structure of a Confined Microsociety" by Drs. Thomas A. Cowan and Donald A. Strickland (Reference 3).

V DIET

The basic diets in all studies were formula diets. In Study #3 a formula diet similar to that in Studies 1 and 2 was employed in the control groups; and the metabolic effects on subjects in this study were compared with those observed on a Gemini-type diet supplied by the National Aeronautics and Space Administration. The diets are shown in Tables 3 through 14.

In experiments 1 and 2 the formula diet (Tables 3 and 4) was prepared in large batches, thoroughly mixed, and the material frozen. In Study #3 the diet (Table 5) was blended in a steam-jacketed kettle; and the finished formula was then lyophilized, ground, and frozen. The material was reconstituted with water before feeding.

In Study #1 a trace mineral mixture was given (Table 6). In Study #2 two mineral supplements were employed so that when protein was removed from the diet sulfate in the amount available from "normal" dietary protein would be substituted by the mineral mix (Tables 7 and 8).

The protein source in all of the experiments was food-grade, dried egg albumin (Carlson's Bakers Supplies). Since raw egg white contains both an anti-tryptic factor and avidin (a protein that binds biotin), two modifications of formula were required: 1) the formula was heated to 60° C. to reduce the antitryptic principle and 2) 200 μg of biotin per 75 g of egg protein was added to counteract the avidin. A mixture of carbohydrate and fat sources was selected so that data relative to protein status would not be dependent upon the presence of specific dietary constituents and thus limit ultimate applications to space feeding. Carbohydrates used were corn starch, a small amount of simpler sugars (Dextr-maltose, Mead Johnson and Co.), and sucrose, in an approximate ratio of 1.5:1.5:1. Equal parts of corn starch and Dextri-maltose were substituted for egg albumin to keep calories constant in the protein-free diet with sucrose unchanged. The fat was derived from approximately equal amounts of corn oil and hydrogenated vegatable fat (Crisco, Proctor & Gamble). In Study #2 when dietary protein of intermediate value was necessary the required portions of the protein and protein-free formula were mixed.

In addition to this, energy was supplied in experiments 1 and 2 from wafers prepared from corn starch, Dextri-maltose, sucrose, fat, and salt (Table 9). The salts were selected to provide approximately the following amounts of minerals

COMPOSITION OF FORMULA DIET

Protein level, g/day	75	0
Liquid		
Egg albumin, g	106	--
Corn oil, g	50	50
Sucrose, g	60	60
"Dextri-maltose", g	173	213
Cornstarch, g	30	70
Citric acid, g	10	10
Biotin, mcg	200	--
Magnesium oxide, g	0.67	0.73
Calcium phosphate (dibasic), g	3.0	3.4
Sodium bicarbonate, g	6.8	6.8
Sodium chloride, g	--	1.7
Flavoring, artificial, g	0.5	0.5
Wafers		
Cornstarch, g	140	140
"Dextri-maltose", g	23	23
Sucrose, g	52	52
"Crisco", g	56	56
Sodium chloride, g	0.6	0.6
Mineral supplement		
Potassium phosphate dibasic, g	4.383	6.080
Potassium hydroxide, g	--	1.348
Beverages		
Coffee, soluble, g	6	6
Tea, soluble, g	4	4
U. C. Prenatal Tablet, each	1	1

COMPOSITION OF FORMULA DIET

Ingredient	75 g. Protein*	0 Protein*
	g/day	
Egg albumin**	102.74	--
Corn oil	50.	50.
Sucrose	60.	60.
Cornstarch	30.	75.
"Dextri-maltose" (Mead Johnson)	178.	228.
Citric acid	5.	5.
Magnesium oxide	0.67	0.73
Calcium phosphate (dibasic)	3.0	3.34
Sodium chloride	5.0	6.5
	ml/day	
Mineral supplement #1	15.	--
Mineral supplement #2	--	45.
Artificial fruit flavoring	0.5	0.5
	mg/day	
Potassium iodide	0.2	0.2
Sodium fluoride	2.0	2.0
Distilled water	to make 900 gm.	

* Diets of intermediate protein content are derived by mixing these diets.

** Amount determined by analysis of each lot of egg albumin used; 200 mcg. of d-biotin is added to daily formula to raise biotin level to that of whole egg equivalent.

Table 5

COMPOSITION OF FORMULA DIET*

Ingredient	Gm/man/day
Egg albumen	103
Sucrose	99
"Dextri-maltose"	177
Cornstarch	150
Corn oil	44
"Crisco"	49
Citric acid	5.0
NaCl	5.0
$K_2HPO_4 \cdot 3H_2O$	4.378
$CaHPO_4 \cdot 2H_2O$	3.000
MgO	0.670
Synthetic flavoring	0.400
	Mg/man/day
NaF	2.0
KI	0.2
Biotin	0.2

*Prepared by blending the egg albumen with sucrose and corn oil and adding this blend to a steam-jacketed kettle containing a mixture of the remaining ingredients in distilled water (ca 250 ml.) heated to 60°C, and holding at 60°C for five minutes, with stirring. The finished formula was then frozen, lyophilized and ground. The daily allowance was divided into four equal portions. Subjects also received 4 packets of decaffeinated coffee (total 10.0 gm.), trace mineral supplement and vitamin tablets.

TRACE MINERAL MIXTURE FOR NASA RESEARCH STUDIES

Formula		Yield*
$FeSO_4 \cdot 7H_2O$	50 mg	Fe^{++} 10 mg
$CuCl_2 \cdot 2H_2O$	5.37 mg	Cu^{++} 2 mg
$ZnCl_2 \cdot 7H_2O$	43.9 mg	Zn^{++} 10 mg
$MnSO_4 \cdot H_2O$	15.4 mg	Mn^{++} 5 mg
NaF	2 mg	F^- 1 mg
$Na_2MoO_4 \cdot 2H_2O$	0.63 mg	Mo^{+++} 0.25 mg
$Cr_2(SO_4)_3 \cdot 15H_2O$	3.2 mg	Cr^{+++} 0.5 mg
$Na_2SeO_4 \cdot 10H_2O$	.0467 mg	Se^{++++} 10 µg
$AlK(SO_4)_2 \cdot 12H_2O$	85 mg	Al^{+++} 4.8 mg
KI	0.2 mg	I^- 0.15 mg
Choline dihydrogen citrate	2.46 gm	1 gm

* And	Na^+	1 mg
	K^+	7 mg
	Cl^-	12 mg
	S^{++++++}	20 mg

MINERAL SUPPLEMENTS FOR LIQUID FORMULAS

	#1* per 6 liters	#2** per 9 liters
$K_2HPO_4 \cdot 3H_2O$	1754.2 g.	944.0 g.
K_2SO_4	-	393.0 g.
Na_2SO_4	-	278.0 g.
H_2SO_4 (conc.)	-	147.0 ml.
Citric acid	600.0 g.	-

	mg/day (15 ml.)	mg/day (45 ml.)
Potassium	1500.	2500.
Sodium	-	450
Phosphorus	594	640
Sulphur	-	1100

*Used in the protein-containing diet

**Added to the protein-free diet to equate the mineral content of the diets.

TRACE MINERAL SUPPLEMENT TO FORMULA DIET*

Formula		Yield
$FeSO_4 \cdot 7H_2O$	50 mg	Fe^{++} 10 mg
$CuCl_2 \cdot 2H_2O$	5.37 mg	Cu^{++} 2 mg
$ZnSO_4 \cdot 7H_2O$	43.9 mg	Zn^{++} 10 mg
$MnSO_4 \cdot H_2O$	15.36 mg	Mn^{++} 4.9 mg
$Na_2MoO_4 \cdot 2H_2O$	0.63 mg	Mo^{+++} 0.24 mg
$Cr_2(SO_4)_3 \cdot 15H_2O$	3.2 mg	Cr^{+++} 0.5 mg
Na_2SeO_3	25 micrograms	Se^{++++} 11 micrograms
$AlK(SO_4)_2 \cdot 12H_2O$	85 mg	Al^{+++} 4.8 mg
Choline dihydrogen citrate	2.4 g	Choline 1 g

*Divided into 3 capsules and given with breakfast, dinner, and supper.

SUPPLEMENTARY FOODS

Wafers	g./day at 3100 kcal. level
Cornstarch	140.
"Dextri-maltose" (Mead Johnson)	23.
Sucrose	52.
"Crisco" (Proctor and Gamble)	56.
Artificial flavoring	0.2

Beverages*	
"Sanka" (General Foods)	13.56 g/day
with deionized water	1080.0 ml/day
Deionized water, chilled	*Ad libitum*, measured and recorded

*Beverage supplement for Study #2;
Study #1 beverage: 6 g of soluble coffee and 4 g of soluble tea.

at any level of protein fed: sodium, 3.1; potassium, 2.8; calcium, 0.8; phosphorus, 1.3; magnesium, 0.5. Particular difficulty was experienced with administration of potassium salts as these are unpalatable and in high concentration irritating to the stomach and bowel. The problem was overcome by dilution and by lowering the pH of the mixture given. These potassium salts were given in Study #1 as a separate mixture, but in subsequent experiments were incorporated in the formula. In Studies 1 and 2 vitamins were supplied by a standard, prenatal supplement compounded at the University of California Medical Center (Table 10). In Study #3 a commercial multivitamin preparation was utilized (Table 11) and in addition the subjects were given α-d-tocopherol, 30 mg/day, in a capsule. The trace minerals administered are shown in Table 8. These are compounded in our own laboratory. The only difference between trace minerals used in Study #1 and in subsequent experiments is that sodium fluoride and potassium iodide are added to the diet in Studies 2 and 3.

During the last phases of the studies, the subjects were usually given diets composed of weighed amounts of conventional foods (Tables 12 and 13). The approximate composition and mineral content of this diet was essentially that of the controlled formula diet.

The components of the formula diet were analyzed individually for content of the nutrients under investigation, and the formula was computed on the basis of these analyses. Periodically, aliquots of all the materials fed were composited; and these composites were analyzed for the appropriate nutrients.

As mentioned, in Study #3 half of the subjects were on the Gemini-type diet. Three menus were provided, and these were fed in sequence 14 times each (Tables 14a,14b,14c). The diet was calculated by the United States Armed Forces NATICK Laboratories to yield an average of 98.29 g protein and 2768 Kcal/day over a 3-day cycle. The daily allowance was divided into 4 approximately equal meals given at 8 a.m., 12 noon, 5:30 p.m., and 9:30 p.m.

In addition to the indicated diets, the men had free access to deionized water. The only requirements were that this water be accurately measured and the amounts recorded. The only other substances taken by mouth were fecal dye markers (100 mg of F.D.C. Blue No. 1 plus 400 mg of methyl cellulose in gelatine capsules) given every 3 or 6 days to delineate the minor metabolic periods for fecal collections and very rarely prescribed aspirin or tincture of belladonna. Subjects were permitted to brush their teeth without any dentifrice and without rinsing or spitting except on 2 occasions during Study #3 when zirconium oxide paste was provided for thorough cleansing.

U.C. PRENATAL TABLETS - FORMULA

I.	**Mineral Phase**		
1.	Ferrous Fumarate	0.022817	Gm.
2.	Potassium Iodide	0.000066	Gm.
3.	Manganous Gluconate	0.001450	Gm.
4.	Magnesium Oxide, heavy	0.000750	Gm.
5.	Copper Gluconate	0.003214	Gm.
6.	Sodium Molybdate	0.001920	Gm.
7.	Zinc Oxide	0.000312	Gm.
8.	Cobalt Chloride	0.001000	Gm.
9.	Lactose	0.010000	Gm.
10.	Zein (as solution)	0.001000	Gm.
	Total:	0.042529	Gms.
II.	**Acid Vitamin Phase**		
1.	Thiamine Mononitrate	0.0018	Gm.
2.	B_{12} 0.1% Triturate	0.0018	Gm.
3.	Riboflavin	0.0015	Gm.
4.	Folic Acid	0.0003	Gm.
5.	Pyridoxine Hydrochloride	0.0040	Gm.
6.	Lactose	0.1731	Gm.
7.	Plasdone "C" (P.V.P.)	0.0120	Gm.
8.	Starch	0.0030	Gm.
9.	Alginic Acid	0.0025	Gm.
	Total:	0.2000	Gms.
III.	**Core Phase**		
1.	Acid Vitamin Granules	0.2000	Gm.
2.	Vitamin A & D Crystals - 500,000 A and 50,000 D + overage	0.0044	Gm.
3.	Coated Ascorbic Acid 95% plus overage	0.0309	Gm.
4.	Vitamin "E" 33.3% Triturate	0.0080	Gm.
5.	Mineral Phase	0.0425	Gm.
6.	Mg. Stearate --- 0.5% ---)		
7.	Starch, dried --- 1% ---)	0.0042	Gm.
	Total:	0.2900	Gms.
IV.	**Coating Phase**		
1.	Calcium Carbonate ppt.	0.75000	Gm.
2.	Niacinamide, screened	0.00750	Gm.
3.	Calcium Pantothenate	0.00273	Gm.
4.	Lactose	0.12000	Gm.
5.	Sodium Lauryl Sulfate	0.00100	Gm.
6.	Starch	0.01617	Gm.
7.	Plasdone "C" (P.V.P.)	0.02000	Gm.
8.	Red	0.00060	Gm.
9.	Carboxy Methyl Cellulose (as 2% solution)	0.00400	Gm.
	Total:	0.92200	Gms.

COMMERCIAL VITAMIN MIXTURE*

	per Tablet
Vitamin B_1 (as mononitrate)	2 mg
Vitamin B_2	3 mg
Niacinamide	20 mg
Vitamin B_6	5 mg
Calcium Pantothenate	10 mg
d-Biotin	50 mcg
Vitamin B_{12}	2 mcg
Vitamin A (as palmitate)	4000 units
Vitamin D	400 units
Vitamin E (as dl-α tocopherol acetate)	35 units
Vitamin K_1	1 mg
Vitamin C	50 mg
Folic Acid	0.5 mg

*Given only to formula-diet subjects.

RECOVERY DIET

Component	Amount g
Whole egg	100
Egg white	50
Milk solids, non-fat	50
Orange juice, frozen conc.	25
Lettuce, head	50
Pea soup, canned, condensed	150
Peaches, canned, water-packed, drained	150
Corn flakes	30
French bread	250
Rice, pre-cooked, dehydrated	50
Vanilla wafers	30
Sucrose	140
Margarine	55
Corn oil	32
Vinegar	as desired
Coffee, soluble	6
Tea, soluble	4

RECOVERY DIET

	Amount, g
Breakfast	
Orange Juice	25
and Glucose	30
Cornflakes with	
Whole Milk	25
Sugar	15
Bread, White	75
Margarine	15
Jelly, Crabapple	20
Sanka	2 cups
Dinner	
Boston Style Baked Beans	300
Bread, Whole Wheat	100
Margarine	15
Lettuce	50
Vinegar	--
Oil	20
Banana	150
Sanka	2 cups
Supper	
Tomato Rice Soup	200
and Oil	12
Bread, White	75
Margarine	15
Milk, Non-Fat	25
Raisins	50
Peanuts	27
Jelly, Crabapple	20
Sanka	2 cups
Snack	
Grape Juice	200

Table 14a

GEMINI DIET

Food Weight, Gemini Menu #1
(grams per serving)

	Natick Predicted Weight	Individual	Subject	Intakes				Average Weight, 14 menu cycles		
Meal A										
Orange drink	21.0	21.0*						21.0*		
Apricot cereal cubes (6 pcs)	36.2	36.2	36.3	36.2	35.9	35.9	36.4	36.1 ± 1.5	(N=87)	(30.0-40.8)**
Sausage patties (2 pcs)	42.6	40.5	42.0	40.7	40.5	40.3	40.1	40.7 ± 1.8	(N=87)	(36.8-44.8)
Cinnamon toast (6 pcs)	16.6	17.2	17.5	17.1	17.6	17.0	17.2	17.3 ± 1.0	(N=87)	(14.2-19.1)
Fruit cocktail	22.5	23.1	23.7	23.4	23.0	23.4	23.6	23.4 ± 1.3	(N=87)	(20.8-26.0)
Meal B										
Chicken and gravy	24.4	24.5	24.3	24.5	24.5	24.5	24.6	24.5 ± 0.7	(N=87)	(23.0-26.2)
Toasted bread cubes (6 pcs)	33.4	34.2	34.3	32.1	34.6	34.8	34.4	34.0 ± 1.1	(N=87)	(32.0-36.5)
Pineapple cubes (6 pcs)	56.4	56.3	55.9	56.7	56.4	56.2	56.6	56.4 ± 1.2	(N=87)	(53.8-59.0)
Cocoa beverage powder	42.0	42.0*						42.0*		
Meal C										
Tuna salad	44.1	44.1	44.1	44.1	44.3	44.1	44.1	44.1 ± 1.0		(42.2-47.0)
Toast (6 pcs)	14.0	15.4	15.2	15.2	15.0	15.3	15.4	15.2 ± 1.0	(N=336	(13.0-20.8)
Apricot pudding	70.0	70.0*						70.0*		
Tea w/sugar	8.0	8.2*						8.2*		
Meal D										
Orange/grapefruit drink	21.0	21.0*						21.0*		
Beef and vegetables	24.1	23.4	23.8	23.8	24.1	23.7	23.6	23.7 ± 1.0		(21.6-28.0)
Potato salad	29.1	28.9	29.0	29.0	29.4	28.6	29.0	29.0 ± 1.3	(N=168)	(24.5-32.0)
Toast (6 pcs)	14.0	15.4	15.2	15.2	15.0	15.3	15.4	15.2 ± 1.0	(N=336)	(13.0-20.8)
Date fruitcake (4 pcs)	58.6	59.9	59.6	59.3	61.4	59.6	61.3	60.2 ± 3.2		(52.8-67.3)

*Bulk packaged and servings weighed at U.C. to 0.01 gm.
**Mean, standard deviation and range of 84 servings unless otherwise noted.

continued

Table 14b

Food Weight, Gemini Menu #2
(grams per serving)

	Natick Predicted Weight	Individual Subject Intakes						Average Weight, 14 menu cycles	
Meal A									
Orange drink	21.0	21.0*						21.0*	
Sugar-coated oat cereal w/milk	24.0	27.0	27.4	27.3	26.6	26.9	27.1	27.0 ± 1.7	(23.8-30.5)**
Bacon & egg bites (6 pcs)	29.4	35.3	34.8	35.0	34.7	34.3	34.9	34.8 ± 1.6	(32.1-38.5)
Beef sandwiches (6 pcs)	39.6	37.3	37.7	38.0	37.4	37.9	37.2	37.6 ± 1.1	(35.5-40.5)
Cocoa beverage powder	42.0	42.0*						42.0*	
Meal B									
Beef bites (6 pcs)	30.6	30.7	30.6	30.5	31.9	31.1	32.2	31.2 ± 2.2	(27.7-36.7)
Potato salad (N=168)	29.1	29.0	28.4	28.7	29.5	29.3	29.1	29.0 ± 1.3	(25.0-32.7)
Toast (6 pcs) (N=336)	14.0	15.4	15.2	15.2	15.0	15.3	15.4	15.2 ± 1.0	(13.0-20.8)
Chocolate pudding	70.0	70.0*						70.0*	
Tea w/sugar	8.0	8.2*						8.2*	
Meal C									
Grapefruit drink	21.0	21.0*						21.0*	
Chicken bites (6 pcs)	29.4	28.8	29.0	29.2	28.9	29.6	29.8	29.2 ± 1.1	(26.4-31.8)
Corn bar	27.0	26.6	25.9	26.9	26.7	26.8	26.2	26.5 ± 1.2	(23.5-30.0)
Peaches	25.0	23.9	23.9	23.3	24.0	24.1	24.8	24.0 ± 1.7	(20.9-27.8)
Brownies (6 pcs)	44.4	45.6	45.9	45.5	46.2	46.2	45.9	45.7 ± 1.8	(42.2-49.5)
Meal D									
Potato soup	49.0	49.0*						49.0*	
Shrimp cocktail	29.4	28.1	28.4	28.8	28.8	28.7	28.3	28.5 ± 0.9	(24.0-30.4)
Toasted bread cubes (6 pcs)	33.4	35.1	34.5	35.2	34.4	34.5	34.4	34.7 ± 1.2	(31.2-37.5)
Tea w/sugar	8.0	8.2*						8.2*	

*Bulk packaged and servings weighed at U.C. to 0.01 gm.
**Mean, standard deviation and range of 84 servings unless otherwise noted.

continued

Food Weight, Gemini Menu #3
(grams per serving)

	Natick Predicted Weight	Individual	Subject	Intakes				Average Weight, 14 menu cycles	
Meal A									
Orange-grapefruit drink	21.0	21.0*						21.0*	
Sugar-coated corn flakes w/milk	36.8	38.2	38.1	38.2	37.9	38.9	38.8	38.3 ± 1.4	(35.0-43.0)**
Bacon squares (4 pcs)	20.8	22.1	21.8	22.0	21.8	21.7	21.9	21.9 ± 0.9	(19.9-24.2)
Peanut butter sandwiches (6 pcs)	40.8	55.6	55.3	55.3	55.6	56.5	54.5	55.4 ± 2.3	(51.0-61.5)
Apricot cubes (6 pcs)	55.2	53.8	53.9	54.4	53.8	54.2	54.1	54.0 ± 1.2	(51.0-57.3)
Meal B									
Salmon salad	42.7	42.8	42.1	42.1	41.9	41.7	41.7	42.1 ± 2.6	(37.3-50.1)
Pea bar	22.0	20.9	20.4	20.7	20.8	20.9	20.6	20.7 ± 0.3	(18.5-22.2)
Applesauce	42.0	42.0*						42.0*	
Gingerbread (6 pcs)	40.8	43.8	43.5	43.9	43.7	44.3	43.4	43.8 ± 1.6	(38.8-47.1)
Tea w/sugar	8.0	8.2*						8.2*	
Meal C									
Orange drink	21.0	21.0*						21.0*	
Chicken and vegetables	20.3	19.4	19.6	18.9	19.9	19.5	19.9	19.6 ± 0.7	(18.1-21.2)
Toast (6 pcs) (N=336)	14.0	15.4	15.2	15.2	15.0	15.3	15.4	15.2 ± 1.0	(13.0-20.8)
Pineapple fruit cake (4 pcs)	57.3	61.1	61.6	61.5	64.3	62.6	62.7	62.3 ± 4.8	(53.5-73.1)
Meal D									
Spaghetti w/meat	16.9	19.4	19.7	20.4	19.9	19.6	19.9	19.8 ± 1.8	(15.0-22.0)
Cheese sandwiches (6 pcs)	51.6	39.4	39.5	39.2	39.4	40.1	40.4	39.7 ± 2.0	(36.4-48.6)
Butterscotch pudding	70.0	70.0*						70.0*	
Tea w/sugar	8.0	8.2*						8.2*	

*Bulk packaged and servings weighed at U.C. to 0.01 gm.
**Mean, standard deviation and range of 84 servings unless otherwise noted

VI GENERAL TEST PROCEDURES

Although the procedures varied slightly in each experiment, the general test protocol was as outlined below. The men were admitted to the research unit in late afternoon, had a normal dinner that evening, and a general discussion and introduction to test procedures was held.

A. Urine and Feces Collection

During Study #1 the urine volume was measured and aliquots prepared from the daily urine. In the middle of Study #2 the procedure was changed, and the daily collections were diluted to a uniform volume with distilled water and aliquots prepared from the diluted urine. All urines were assayed daily for nitrogen and creatinine. The aliquots prepared were pooled either in 3- or 6-day pools. The pooled specimens were then analyzed for the appropriate material (usually calcium, magnesium, sodium, potassium, phosphorus, and chloride) in all experiments; and in Study #3 citrate hydroxyproline and catecholamines in addition.

Fecal dye markers were administered with breakfast on the first day of the controlled feeding and each 3 to 6 days thereafter. It was found early that when the dye markers were administered on a 3-day basis it would usually be impossible to differentiate the metabolic periods; and therefore most 3-day periods were pooled into 9-day periods. The stool collections were divided according to passage of the dye, and at the termination of each experiment the subjects were discharged after the terminal dye marker appeared. The weight of the stools was recorded after each defecation. The 6- or 9-day collections were diluted to uniform weight with distilled water and blended thoroughly in a colloid mill which homogenized them quite uniformly. Generally, the analyses were for the same elements as were measured in urine.

B. Temperature, Pulse, Respiration, Weight

The temperature, pulse, and respiration of the subjects was checked twice daily by the nurse; and each morning the men were weighed clad only in underwear immediately after voiding.

C. Body Composition

In Studies 1 and 2 body composition was estimated from specific gravity underwater weighings and anthropometry with the assistance of Dr. Albert Behnke. The determinations for Study #1 are incomplete and have not been reported.

In Study #2 body composition was estimated from specific gravity obtained by underwater weighing and helium dilution (the helium dilution determinations were performed for us by Dr. William Siri), the total body water by dilution of tritiated water and anthropometry; in Study #3 body composition was estimated from specific gravity, underwater weighing, total body water, and anthropometry; and 1 subject was studied by helium dilution.

D. Blood Samples

In Studies 1 and 2 blood samples were collected at each change in major metabolic period and in Study #3 after every second metabolic period. The amount of blood withdrawn was weighed and corrections were made for this material withdrawn in corrected balance studies. The analyses carried out on blood included hemaglobin, white blood count and differential, total whole blood protein, total serum protein, electrophoresis of serum on cellulose acetate, protein bound iodine, blood urea nitrogen, uric acid, glucose, cholesterol, serum glutamic pyruvic transaminase, and direct and indirect serum bilirubin. Samples have been saved for amino acid analyses; and these are currently being studied. In addition, in Study #3 triglycerides, lactic acid and ammonia in relation to exercise, and vitamin E at the beginning and end of the experiment were determined.

E. Integumental Nitrogen Loss

During Studies 1 and 2 integumental losses were collected throughout the experiment for nitrogen determinations. In Study #3 sweat and skin losses and beard were collected during 2 of the 6-day periods.

Samples for determination of sweat and skin losses were obtained as follows. After a thorough scrubbing with soap, warm water rinse, thorough rinse with deionized water, and drying with a towel rinsed in deionized water, the subjects donned a comfortable-fitting, one-piece pair of cotton underwear which had short sleeves. This type of a garment was selected to not induce perspiration or inhibit evaporation and to thereby simulate the environmental conditions of the resting, nonsweating individual. Each subject was given a labelled towel and instructed to use it to dry any visible sweat from his face, neck, and arms during the collection period. The underwear and towel had been thoroughly washed, soaked in 0.05 acetic acid for 24 hours, rewashed, and rinsed in deionized water. The subjects were cautioned against contaminating the underwear with food or excrement. The subjects wore the underwear for the specified length of time, either 3 or 6 days. At the end of this time the subjects removed the underwear and they were then thoroughly bathed in 37.85 L of deionized water containing 10 ml of 10 percent

"Brij 35" (polyethylene lauryl alcohol detergent). All the body surfaces, including the scalp, were thoroughly scrubbed; and a sample of the bath water was saved for analyses.

The procedure for extracting the sweat and skin losses from the underwear and towels was slightly modified during the experiments. Originally, the underwear and towels were placed in an enamel container containing 3500 ml of 0.1 percent sulfuric acid, agitated, and heated to boiling; the container was covered and the underwear was permitted to soak for 24 hours. (A 24-hour period was an adequate length of time for the ions in the underwear and those in the acid solution to be in equilibrium.) Before a sample of the solution was taken, the material was again agitated. This method was altered because it was suspected that the hot sulfuric acid might interfere with the release of the cellular debris or coagulated protein thought to be present in the underwear; the extracting solution was changed to 3785 ml of 0.05 percent acetic acid beginning with the last metabolic period of Study #1. However, the values obtained with the new method were not different than those obtained with the old.

During Study #1 the nitrogen determination of the bath water and laundry water were done separately. In Studies 2 and 3 aliquots of each subject's bath and laundry water were pooled and determinations were done on only the single sample. During the first Study only the bath water samples were concentrated from volumes of 1 to 2 L down to 50 and 100 ml. In Studies 2 and 3, 1 L of the 37.85 L of bath water and 100 ml of the 3.78 L of laundry water were concentrated together and brought to a volume of 100 ml. All concentration was done in open glass vessels on a gas burner. The nitrogen was determined by the micro-Kjeldahl procedure.

In Study #3 the nutrient losses in sweat were also measured. An attempt was made to determine the differences in nutrient loss between total body sweat and sweat collected from different locations of the body. The sweating was studied during the bicycle work test described below.

Before each bicycle work test, the subject was bathed thoroughly in deionized water and clad only in chemically washed shorts and socks and weighed on a balance accurate to ±10 g. Weighed absorbent patches were attached to the body by means of a plastic cover and adhesive at 3 locations: midchest, midback, and the center of the arm. A plastic bag was slipped over the left forearm and attached just below the elbow. After work, the subject was reweighed and the measured weight loss was construed to mean total body sweat loss. Corrections in calculation for respiratory loss were not made. The absorbent pads were weighed immediately upon removal to determine the amount of sweat collected, and the volume of sweat collected in the plastic arm bag was recorded. The subject was bathed in 37.85 gal of deionized water containing 10 ml of "Brij"; a sample of the bath water was reserved. The socks and shorts were treated as mentioned above. The absorbent pads were extracted immediately and repeatedly with distilled water; and the extract was analyzed for sodium, potassium, nitrogen, urea, and lactic acid. The same constituents were measured in the arm-bag sweat directly, as was osmolarity. In the bath laundry sample, calcium, magnesium, and chloride content were measured in addition; but lactic acid was not measured because the sample was not suitable.

F. Beard Collection

At the beginning of the first metabolic period, each subject shaved himself and the shavings were discarded. The subjects with mustaches were instructed to trim them to a desired length. On the morning of each new collection the subjects, using only soap and brush provided, shaved themselves with safety razors. Those subjects with mustaches trimmed them to their original length.

All whiskers were washed into small enamel containers provided, were filtered through a buchner funnel onto filter paper, and were rinsed with deionized water until no trace of soap was evident. (If the subjects wished to shave more than once during a 3- or 6-day collection period, they were permitted to do so providing all the whiskers were saved.) The whiskers were allowed to dry on the filter paper; and, after careful removal from the filter paper, they were rinsed with acetone and transferred to preweighed weighing dishes and dried with repeated washings of acetone and air. The weights were recorded to the nearest tenth of a mg. In Study #1 the whiskers were placed in envelopes to be saved for nitrogen analysis. This proved to be a poor arrangement because some of the whiskers were lost. In Studies 2 and 3 the whiskers were placed directly into the macro-Kjeldahl flasks after being weighed.

G. Scalp Hair and Nail Collection

The scalp hair was cut to the subject's desired length on the first day of the study. At the end of each dietary change (or in Study #3 at the termination of the experiment), the hair was trimmed to the original length. The subjects were instructed not to use any material on their hair. During Study #1 the hair was collected on an oilcloth mat and transferred to a manila envelope. In Studies 2 and 3 the hair was collected directly onto a large sheet of paper which was folded as an envelope.

The hair was transferred to filter paper, weighed to the nearest hundreth of a g, and placed in a macro-Kjeldahl flask. The hair that was removed in daily combing and brushing was saved in an envelope with the fingernail and toenail clippings and collected at the end of each metabolic period in the first two studies. In Study #3 the nails and extra hair were collected separately.

The subjects were instructed to trim their nails to a desired length on the first day of the study and then to trim them to the same length at the end of each metabolic period. The nails were weighed and the weights were recorded to the nearest tenth of a mg. The samples were added to the macro-Kjeldahl flasks.

In Studies 1 and 2, nitrogen determinations were done on the combined hair, nails, and whiskers for each major metabolic period. In Study #3 the 2 whisker collections were pooled for nitrogen; and separate nitrogen analyses were done on scalp hair and nails.

H. Nail Growth Measurement

Nail growth was measured by a modification of the Lunula Photographic Method (Reference 1). The edge of the lunula of the thumbnail was lightly scratched with a sharp scalpel. India ink was spread on the scratch and wiped off with a damp cloth. The thumb was placed on a raised, dark surface and care was taken to avoid pressing the thumb. A Polaroid MP-3 Multipurpose View Camera was clamped vertically over the thumb. The bellows was extended to maximum and the camera focused to give a sharp photograph with a magnification of 1.15. Polaroid 55/pn film was used, and the area was illuminated by regular incandescent bulbs. The nails were marked and photographed at specified time intervals, usually corresponding to major metabolic periods.

The nail growth was determined from the positive print which was placed under a dissecting microscope at 40 X magnification. The eyepiece was replaced by a Wilde-Heerbrug Filar Micrometer Ocular, and the distance between marks was measured by the number of degrees the micrometer was turned (675 = 1 mm). Each measurement was taken 6 times. An average of the measurements was taken and converted to mm of growth per day.

I. Activity

The daily activity program in Studies 1 and 2 included 60 minutes of walking on the treadmill set at 3.0 mph and 10 percent grade and 10 minutes of group calisthenics per day. In Study #3 the activity was decreased to 30 minutes of walking on the treadmill.

The subjects were asked to limit exercise to these tasks, but activity was quite variable. Some men spent most of their free time resting or in quiet occupations (reading, card games, painting, etc.), while others were much more active (dancing, bongo drum playing, kite flying). It was intended that hours of sleep be uniform, and the subjects were to retire at 11 p.m. with lights out at 11:30 p.m. However, these rules could not be effectively enforced. The men often slept during the day and stayed awake late at night engaged in conversation or with clandestine radio and, occasionally, television.

During Studies 1 and 2, the activity program was kept constant. In Study #2, 2 of the subjects appeared to exhibit significant weight changes; and these individuals had their caloric intake adjusted to attempt to compensate for these weight changes. However, in Study #3 about a third of the men adjusted their work-rest cycles so they were able to maintain body weight constant at the given caloric intake. After 4 metabolic periods of 6 days, however, those men who were losing weight were exempted from programmed activity and the treadmill work was doubled for those men who showed weight gains.

In Studies 1 and 2, physical performance was studied initially and at each change in major metabolic period. In Study #3 the performance was examined at 2-week intervals. Muscular strength (hands, legs, and back) was measured by means of dynamometers. In Study #2 examination of pulmonary ventilation, oxygen uptake, and carbon dioxide production were introduced while the subject was performing short intervals of increasing work load on a bicycle ergometer. It was only with Study #3 that the techniques were worked out sufficiently well to report this data. In addition to this, electrocardiograms and heart rates were evaluated in conjunction with each work test.

The work tests were performed at 450, 900, and 1200 kgm/min. The plan for the work test was as follows: the subject was resting, then subjected to the 450 kgm/min test for 3 minutes; allowed to rest for 2 minutes, and the tests then repeated at the 900 kgm/min level for 3 minutes; rest for 2 minutes and then at the 1200 kgm/min level (when the subject was capable of performing at this rate); then 3 minutes of rest. In Study #3 blood samples were taken before and after the work test at the 1200 kgm/min level and analyzed for ammonia and lactic acid.

In order to test the integrity of the vasomotor system, the blood pressure, pulse, and respiration response to changing from the supine to standing position with the subject fixed in the tilt table was studied. In Studies 1 and 2 these changes were observed at each major metabolic period change; in Study #3 this was observed on 3 occasions at about the 10th, 22nd or 23rd, and 32nd to 39th day of the study. In the performance of this test the subjects were taken from a supine position to standing position at intervals of 7 minutes with a 30° change at each time interval.

The basal metabolic rate was determined again during each major metabolic period in Studies 1 and 2. These measurements were not performed in Study #3.

In Study #3 the intestinal gas producing quality of the diets was determined for 12 hours on 2 occasions by simultaneous measurement of the flatus obtained by rectal tube and analysis of intermittent samples of expired air. Concentration of carbon, oxygen, nitrogen, hydrogen, and methane was determined in respiratory gases and in flatus. The total flatus production was estimated from gravimetric determination of total carbon dioxide captured by a tube filled with ascarite, the total being derived by integration from percentage composition of CO_2 of the flatus samples obtained before removal of the CO_2. Breath gases were measured on each subject at least one additional time when flatus was not collected. After the scheduled experiment ended, those subjects who were willing to remain were fed a test meal of dry beans; and flatus and respiratory gases were again analyzed for comparative purposes.

Beginning with Study #2 various tests were introduced to measure complex reaction time and visual responsiveness. The former was determined by a simulated driving test; visual responsiveness was determined by measures of dark adaptation, loss of hue of high-intensity monochromatic light, and flicker fusion. Arithmetic skills were tested by speed and accuracy of addition of five 2-digit numbers as a measure of short-term memory and concentration. Verbal learning ability was judged by a test involving free recall of self-imbedded sentences (Reference 4).

The psychological personality measurements included the Minnesota Multiphasic Personality Inventory, the California Psychological Inventory, the Adjective Check List, and the Omnibus Personality Inventory. The Strong Vocational Interest Blank was administered in Study #3. In Studies 2 and 3, sociological measurements made utilized (a) an inter-group relations attitude inventory and (b) a group activity inventory which classified the individual activity at 10 randomly chosen periods throughout the day. The experimental area was isolated from the external social environment.

Visitors were allowed at regular intervals in Studies 1 and 2. However, this procedure interfered with certain of the requirements for attendance at specified activities; and therefore in Study #3 visitors were prohibited but telephone communication and mail were allowed. The external staff was stabilized and held constant. There were approximately 12 staff members regularly assigned to duty with whom the subjects had contact at various times throughout the day and night and there was always a staff member on duty.

J. Saliva and Semen Analysis

In Study #1 saliva was collected every 3 to 6 days by having the individual chew on a small piece of paraffin and spit into a container provided. This was analyzed for nitrogen content. Also during this experiment semen was collected every 3 to 6 days by having the subject collect an ejaculate in a weighed container provided, and the samples were analyzed for total nitrogen and total sperm. However, because determinations on these fluids showed quite wide variations for each subject, they were not continued in subsequent studies.

VII RESULTS AND CONCLUSIONS

A. Body Weight and Composition

Body weight data are shown in Figures 1, 2, and 3a,3b (Subject 0104 of Study #1 is subject 0205 in Study #2, and subject 0103 of Study #1 is subject 0204 in Study #2.)

In Study #1 it is noted that over the 60-day period there was a slight weight gain in 3 of the subjects and a slight weight loss in 1. A considerable part of the weight increase in the subjects in this Study occurred in the last 6 days of the Study which represented the recovery diet and return to "normal" food.

Examination of the data in Study #2 reveals little significant weight change in 4 of the subjects over a considerable length of time; however, subject 0204 (0103 in Study #1) did continue to gain weight and at the end of the experiment was approximately 5 kg heavier than at the beginning of Study #1, whereas subject 0205 (0104 in Study #1) continued to lose weight until his intake was increased to 3,550 Kcal.

In Study #3, 3 of the Gemini-diet subjects lost less than 1 kg of body weight, 2 lost between 1 and 2 kg, and 1 gained 2 kg. Increasing the programmed work of the latter subject from 1/2 to 1 hour of treadmill walking daily failed to influence his rate of weight gain. Among the formula group in Study #3, 2 subjects lost less than 1 kg of body weight, 1 lost 1.6 kg, and another lost 3.8 kg. The other subjects gained 0.8 and 1.5 kg, respectively. Discontinuance of treadmill work tended to reduce the rate of weight loss in 2 of the subjects; and increasing work tended to minimize a slight tendency to gain in another. The rate of gain was unaffected by increased programmed work in the fourth subject.

The relationships between body weight and caloric intake can better be seen in Tables 15, 16, and 17. From this data it appears that the changes in body weight are quite minimal considering the wide variation in caloric intakes relative to body size. Since the caloric intake was reduced in Study #3 compared with that of Studies 1 or 2, comparisons between these studies are quite interesting. Weight loss of more than 1 kg was associated with intakes of 32 and 35 Kcal/kg among Gemini subjects and 29 to 31 Kcal/kg for formula subjects. Intakes of 37 to 39 Kcal/kg were not sufficient to maintain or increase weight among Gemini subjects but did so in the case of the formula subjects in Study #3. In Studies 1 and 2 it is noted that weight loss was associated with caloric intake of 37 to 39 Kcal/kg and that weight maintenance appeared to occur between 40 and 43 Kcal/kg and weight gain at

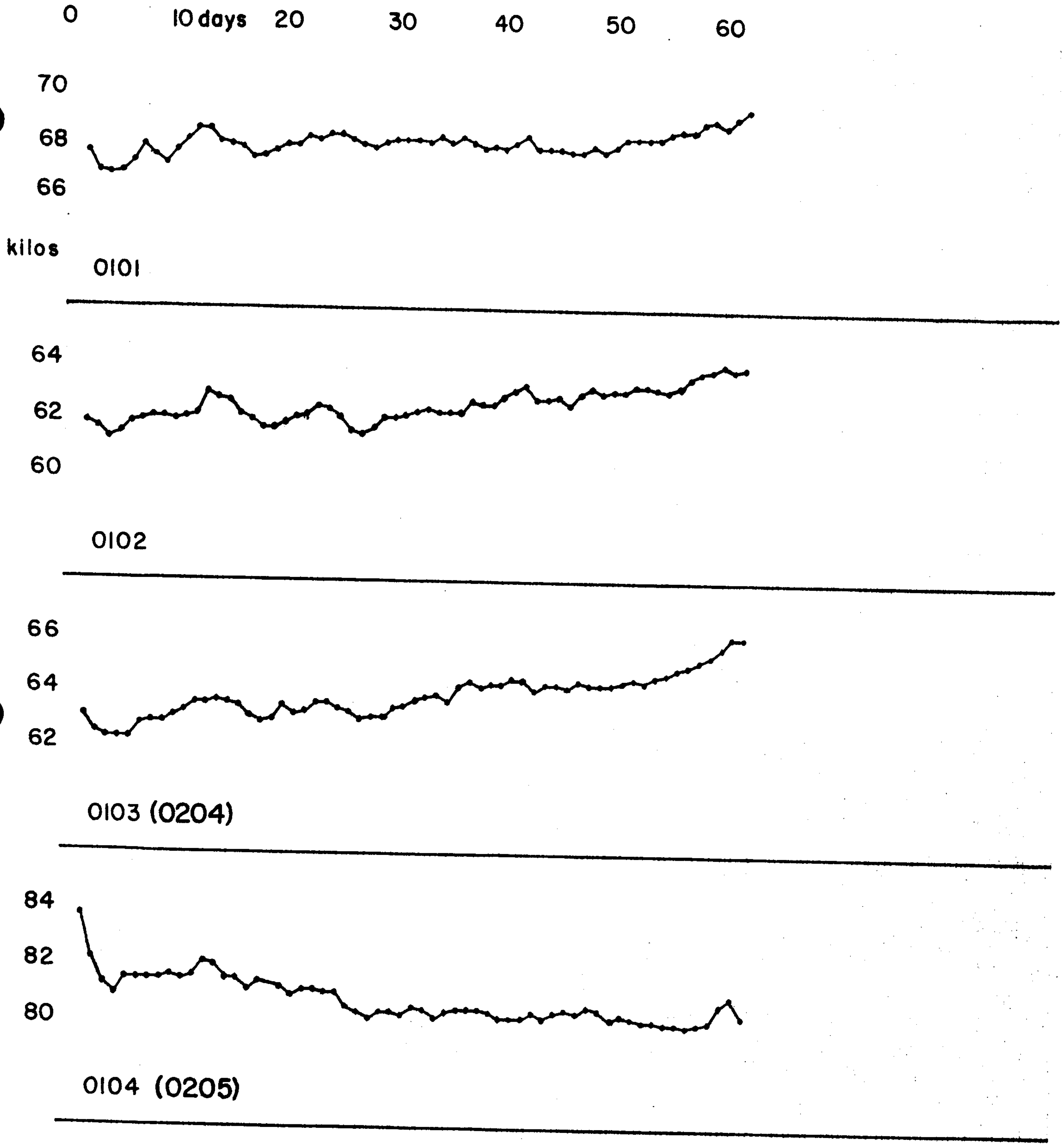


FIG. 1 DAILY BODY WEIGHT PENTHOUSE STUDY I

AVERAGE DAILY CALORIC INTAKE 3200 kcal

ONE HOUR DAILY TREADMILL WORK

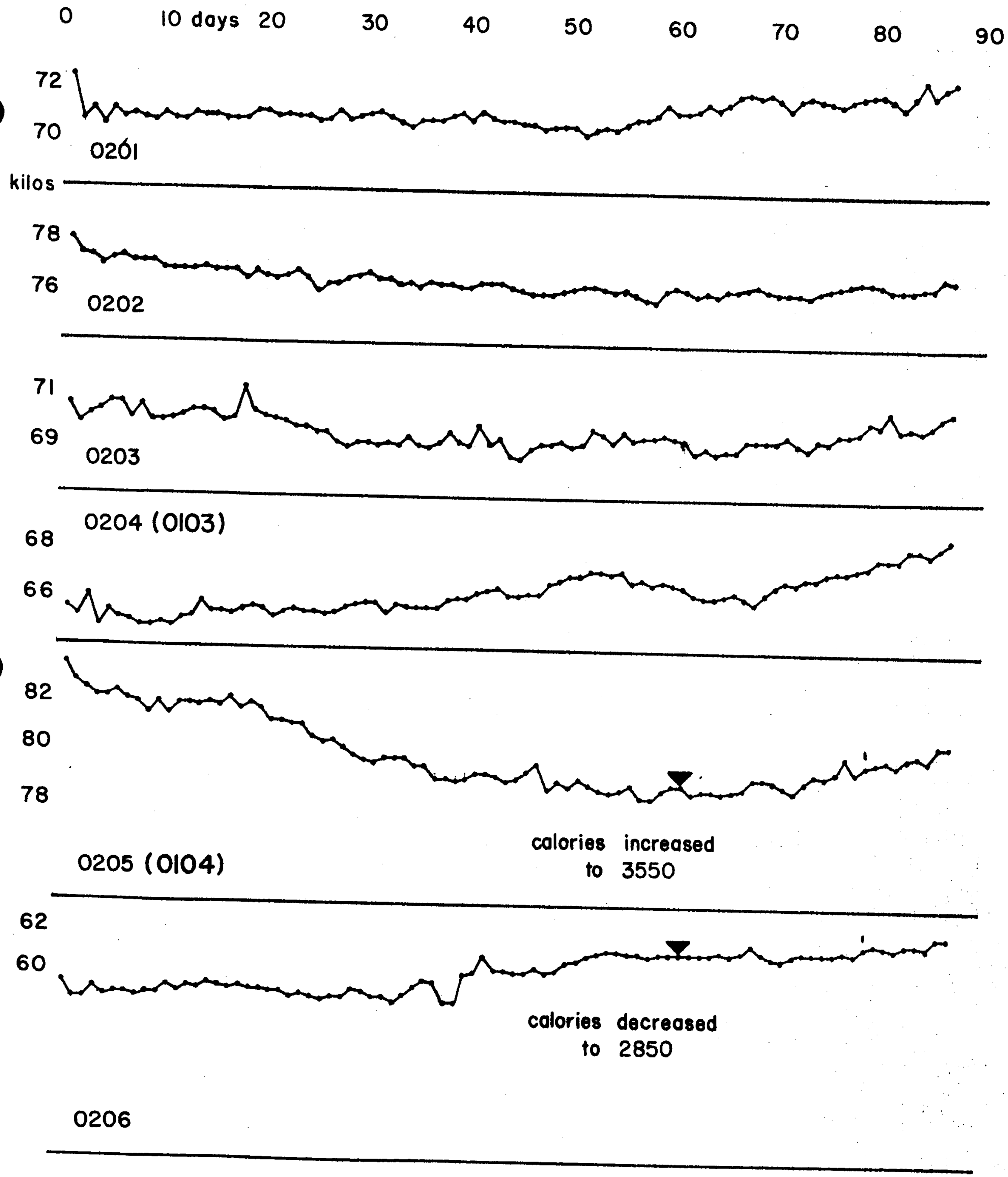
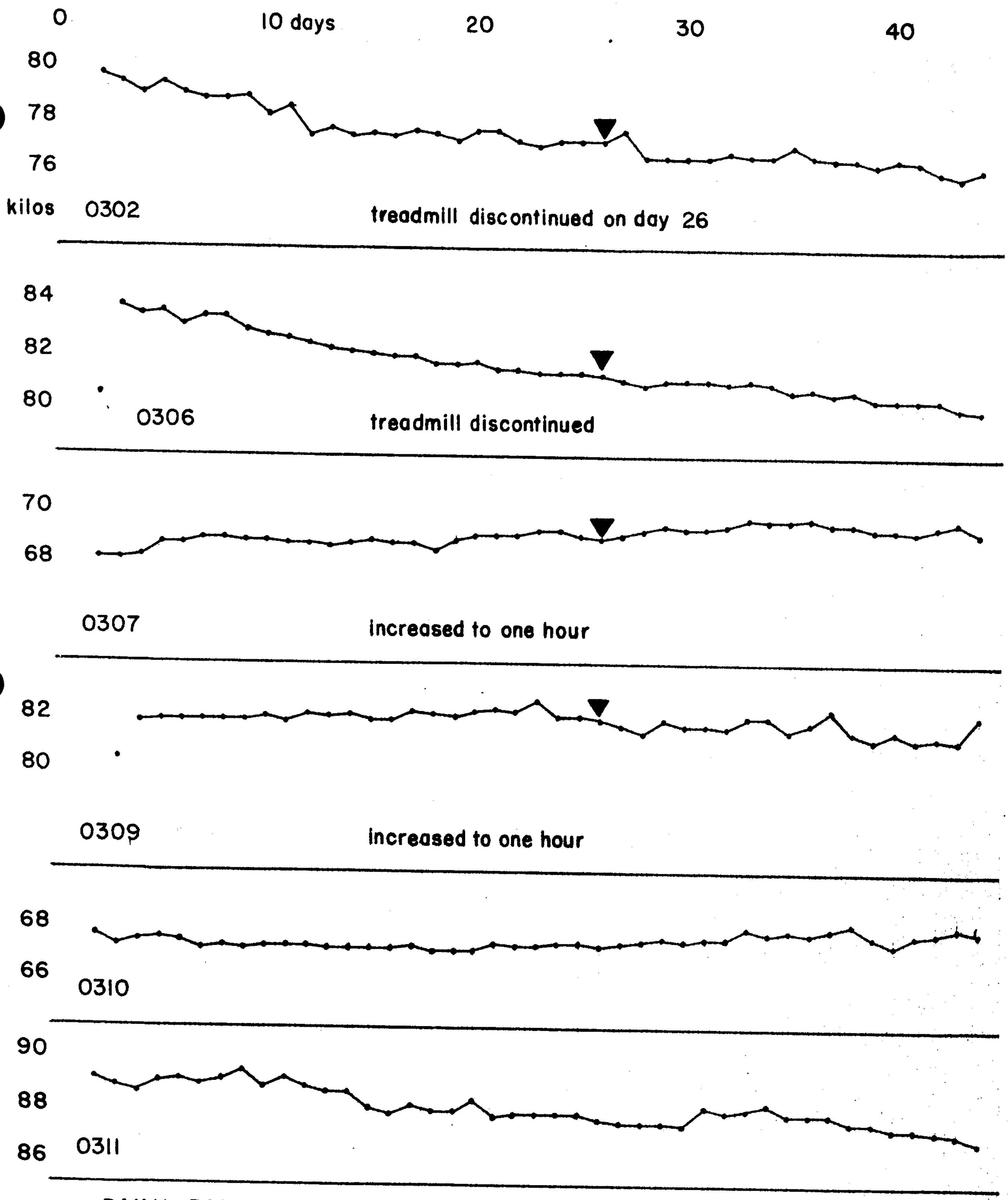


FIG.2 DAILY BODY WEIGHT PENTHOUSE STUDY 2
AVERAGE DAILY CALORIC INTAKE 3200 kcal
ONE HOUR DAILY TREADMILL WORK

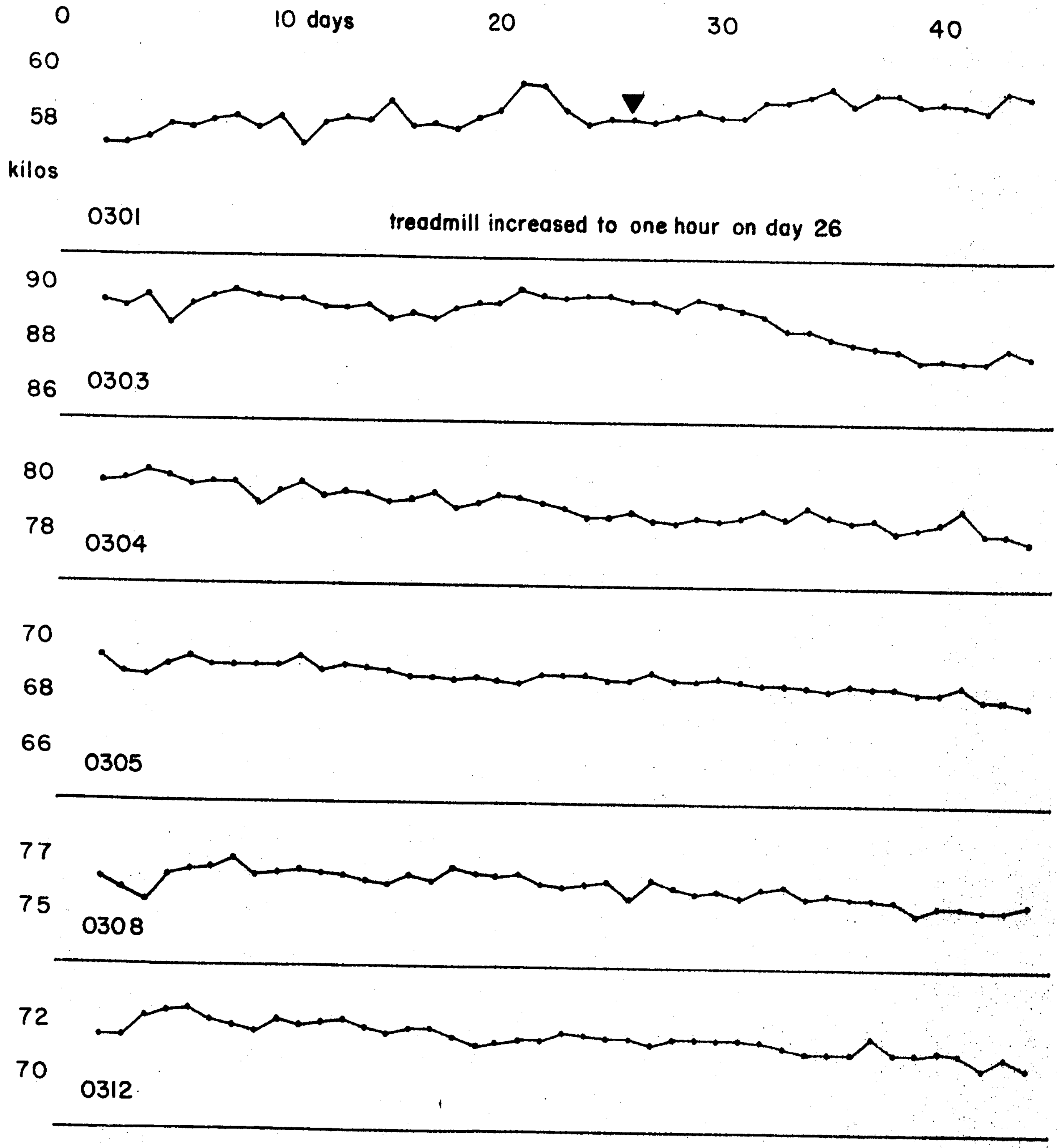


DAILY BODY WEIGHT PENTHOUSE STUDY 3 -- FORMULA SUBJECTS

FIG. 3a

AVERAGE DAILY CALORIC INTAKE 2800 kcal

HALF HOUR DAILY TREADMILL WORK, except as noted



DAILY BODY WEIGHT PENTHOUSE STUDY 3 -- GEMINI SUBJECTS

FIG. 3b

AVERAGE DAILY CALORIC INTAKE 2800 kcal

HALF HOUR DAILY TREADMILL WORK, except as noted

CALORIC AND NITROGEN INTAKE AS RELATED TO BODY WEIGHT

Subject	Period	B.W. kg	Caloric Intake per day	Caloric Intake per kg B.W.	Nitrogen Intake g/day	Nitrogen Intake g/kg B.W.
0101	1	67.7	3062	45.2	12.7	0.188
	2	68.0	3107	45.7	13.2	0.194
	3	68.0	3138	46.1	.62	0.009
	4	68.3	3190	46.7	13.7	0.201
0102	1	62.0	3062	49.4	12.7	0.205
	2	61.9	3097	50.0	13.2	0.215
	3	62.4	3100	49.5	13.3	0.212
	4	63.2	3162	50.0	13.6	0.215
0103	1	62.7	3062	48.8	12.7	0.203
	2	63.2	3097	49.0	13.2	0.209
	3	63.4	3100	48.9	.62	0.009
	4	63.7	3167	49.7	13.7	0.215
0104	1	81.7	3062	37.5	12.7	0.155
	2	80.7	3097	38.4	13.2	0.163
	3	80.2	3138	39.1	13.3	0.166
	4	80.1	3113	38.9	13.6	0.170

CALORIC AND NITROGEN INTAKE AS RELATED TO BODY WEIGHT

Subject	Day	Body Weight, kg	Intake/kg Body Weight kcal	Intake/kg Body Weight Nitrogen, mg
0201	10	71.0	42	174
	20	71.1	42	174
	40	70.8	38*	142
	60	71.2	43	174
	80	72.0	43	171
0202	10	76.8	39	161
	20	76.6	39	162
	40	76.2	40	162
	60	76.3	40	163
	80	76.5	40	161
0203	10	69.9	43	177
	20	70.1	46	9
	40	69.0	44	46
	60	69.4	45	55
	80	70.0	44	176
0204	10	64.9	46	191
	20	65.5	48	59
	40	66.0	41	153
	60	66.6	48	8
	80	67.7	45	182
0205	10	81.8	37	151
	20	81.6	39	8
	40	78.9	39	41
	60	78.7	40	48
	80	79.7	43	155
0206	10	59.4	51	208
	20	59.6	54	11
	40	60.2	50	206
	60	61.1	51	62
	80	61.6	45	200

*Change in diet lot; not yet readjusted.

CALORIC AND NITROGEN INTAKE AS RELATED TO BODY WEIGHT

Subject	Body Weight, kg Day 3	Body Weight, kg Day 43	Average Daily Intake/Kg Body Weight (Days 4-6) kcal	Average Daily Intake/Kg Body Weight (Days 4-6) nitrogen, mg.
Gemini Group				
0301	57.1	59.2	49	272
0303	89.0	87.8	32	175
0304	79.8	78.0	35	195
0305	68.7	67.9	41	227
0308	75.8	75.2	37	205
0312	71.4	70.8	39	215
Formula Group				
0302	79.3	75.8	33	154
0306	83.7	79.9	31	146
0307	68.0	69.5	38	178
0309	81.7	81.1	32	149
0310	67.0	67.8	39	181
0311	88.6	87.0	29	137

levels above this. The two important differences between these studies were that in Studies 1 and 2 the individuals performed for 1/2 hour per day longer on the treadmill and that since there were only 4 or 6 individuals in these studies there was less crowding and thus potentially more possibility for nonscheduled activity. Since the energy expenditure of walking on a treadmill at 3.0 mph on a 10 percent grade for 30 minutes would amount to an increment of approximately only 100 Kcal, this difference in response to caloric differences can not be explained by this small difference. These observations point out the importance of long-term observation before attempting to make deductions regarding the significance of activity and caloric expenditure in weight change.

In Tables 18 and 19 are shown measurements of body composition in Studies 2 and 3. As can be noted, correspondence among the various methods of measuring body composition was quite poor. What is quite distrubing is the lack of reproducibility (in our hands at least) between replicate measurements using the same method, particularly that of underwater weighing. The reasons for these discrepancies have been widely discussed and are quite well known: small differences in underwater weighing and hence estimation of specific gravity lead to significant differences in interpretation as body fat. Because of the variations noted, no one method seems to be superior to any other. Furthermore, the methods are certainly much too insensitive to interpret what changes in body composition lead to the changes in weight noted above. Those individuals who appeared to be gaining weight (which was most likely fat), particularly subjects 0204 and 0206, show no changes in body composition corresponding to the changes in weight observed. These data are unfortunately also of little help, because of the wide variation observed, in enabling us to interpret some of the nitrogen balance data discussed below.

BODY COMPOSITION ESTIMATED BY VARIOUS METHODS

Subject and Period	Body Weight in air (kg)	Density: Underwater Weighing	Density: Helium Dilution	Total Body Water T_2O (kg)	Lean Body Weight, kg, Calc. from: Underwater Weight*	Lean Body Weight: Helium Dilution	Lean Body Weight: Body Water +	Lean Body Weight: Anthropometry**	Percent Body Fat: Underwater Weight*	Percent Body Fat: Helium Dilution	Percent Body Fat: Body Water +	Percent Body Fat: Anthropometry**
0201												
Initial#	70.7	1.059			59.32			61.7	16.1			12.7
I	71.4	1.054			58.98				17.4			
II	71.3	1.052			58.25				18.3			
IV	72.3	1.078			67.53				6.6			
V	71.9		1.049	46.45		58.21	63.46			19.6	11.74	
0202												
Initial	77.5	1.050			62.62			62.0	19.2			20.0
I	76.9	1.049			61.75				19.7			
II	76.7	1.053			63.05				17.8			
IV	76.1	1.047			60.42				20.6			
V	76.6		1.050	43.33		61.97	59.19			19.2	22.73	
0203												
Initial	69.1	1.077			57.84			66.2	16.3			3.3
I	70.3	1.062			60.67				13.7			
II	68.8	1.066			60.61				11.9			
IV	69.1	1.060			59.01				14.6			
V	69.7		1.068	46.02		62.48	62.87			11.0	9.80	
0204												
Initial	65.1	1.055			54.10			61.4	16.9			5.7
I	65.4	1.064			57.03				12.8			
II	66.2	1.056			55.34				16.4			
IV	66.5	1.054			54.93				17.4			
V	67.3		1.044	42.85		53.04	58.54			22.0	13.02	

continued

Subject and Period	Body Weight in air (kg)	Density: Underwater Weighing	Density: Helium Dilution	Total Body Water T_2O (Kg)	Lean Body Weight, kg, Calc. from: Underwater Weight*	Helium Dilution	Body Water+	Anthropometry**	Percent Body Fat: Underwater Weight*	Helium Dilution	Body Water+	Anthropometry**
0205												
Initial	82.3	1.062			71.02			69.1	13.7			16.1
I	81.7	1.068			72.71				11.0			
II	79.6	1.053			65.43				17.8			
IV	78.8	1.063			68.32				13.3			
V	79.3		1.046	49.08		63.20	67.05			21.1	15.45	
0206												
Initial	57.1	1.058			48.25			54.9	15.5			3.8
I	59.9	1.051			48.64				18.8			
II	59.4	1.054			49.06				17.4			
IV	61.0	1.034			44.65				26.8			
V	61.3		1.053	37.58		50.80	51.34			17.8	16.25	

* Keys, Ancel, and J. Brozek, "Body Fat in Adult Man," PHYSIOL REV, <u>33</u>, 245 (1953).
Percent body fat = 100 (5.120/0 - 4.684).

** Behnke, R. N., "Anthropometric Evaluation of Body Composition Throughout Life," ANNALS N Y ACAD SCI, Part 2, 450 (1963).
LBM = $(\text{sum of diameters}/33.5)^2 \times \text{height}^{0.7} \times 0.263$.

\# End of each designated period.

\+ LBM = TBW 100/73.2

Table 19

BODY COMPOSITION DETERMINED BY VARIOUS METHODS

Formula-Diet Subject		Weight in Air kg	Density/ Underwater Weighing	% Body Fat Computed from Density	Body Water (T_2O)	Anthro-pometry	Probable Lean Mass kg
0302	a*	79.3	1.082	5	8	7	75
	b	76.9	1.075	8	--	--	71
0306	a	84.6	1.069	11	14	17	73-75
	b	80.5	1.040	24	22	--	61
0307	a	68.7	1.040	24	22	8	52
	b	69.5	1.036	26	26	--	51
0309	a	83.6	1.071	10	14	17	72-75
	b	81.8	1.035	26	26	--	60
0310	a	67.1	1.058	16	14	9	56
	b	68.4	1.040	24	20	--	52
0311	a	88.6	1.021	33	25	16	59
	b	87.2	1.025	31	32	--	60

continued

Penthouse Study #3
Body Composition Determined by Various Methods

Table 19
continued

Gemini-Diet Subject		Weight in Air kg	Density/ Underwater Weighing	% Body Fat Computed from Density	Body Water (T_2O)	Anthro-pometry	Probable Lean Mass kg
0301	a*	56.4	1.047	21	--	9	45
	b	59.4	1.046	21	23	--	47
0303	a	90.2	1.050	19	20	22	73
	b	88.1	1.056	16	29	--	74
0304	a	80.1	1.055	17	--	13	66
	b	78.5	1.052	18	26	--	64
0305	a	69.8	1.064	13	15	13	61
	b	68.6	1.047	21	18	--	54-56
0308	a	76.1	1.067	12	12	8	67
	b	75.5	1.061	14	21	--	65
0312	a	70.7	1.042	23	18	15	54
	b	71.6	1.037	25	26	--	54

*a = Test day 1 or 2
b = Test day 43 or 44

B. Urinary Creatinine

Urinary creatinine excretion is shown in Figures 4, 5a,5b, 6a,6b. It can be noted that excretion correlates moderately well with body size. However, all subjects in Studies 1 and 2 and those receiving the formula diet in Study #3 show a steady decline in creatinine excretion during the course of the Study. Therefore, any attempt to calculate lean body mass from creatinine excretion or to express this as any function of muscle or lean body mass would be unreliable (Table 20). This decline was quite steady with time, but with variable rates for each subject which appeared to be irrespective of the changes in protein content of the diet.

In Study #3 the excretion was reasonably uniform from day to day among the subjects receiving the Gemini diet, although the values are less constant than is often assumed to be the case. However, no decline with time was noted in the creatinine excretion in subjects receiving the Gemini diet.

At present we are unable to offer an explanation of this fall in creatinine and cannot judge whether the process responsible represents an adverse reaction. The conversion of creatine to creatinine is believed to be a function only of muscle. In the normal individual creatine is produced by the liver, and creatinine is produced from this by the muscle, the total creatinine and creatine, as well as the ratio, being quite constant. This decline noted, therefore, might indicate an alteration in creatine synthesis due (a) to inadequate precursors or (b) to inadequate synthesis by the liver or might indicate an inability of the muscle to accomplish the conversion properly.

It is our intuitive belief that this process represents some inadequacy of the formula diet. This attitude reflects our bias to accepting constant value as indicative of proper functioning homeostatic mechanism and therefore good. It is possible, however, that the decline indicates some improved efficiency of metabolism and improved adaptation. But on the basis of this finding, until we have an adequate explanation of this decline, we are reluctant to accept the formula diet as proved adequate.

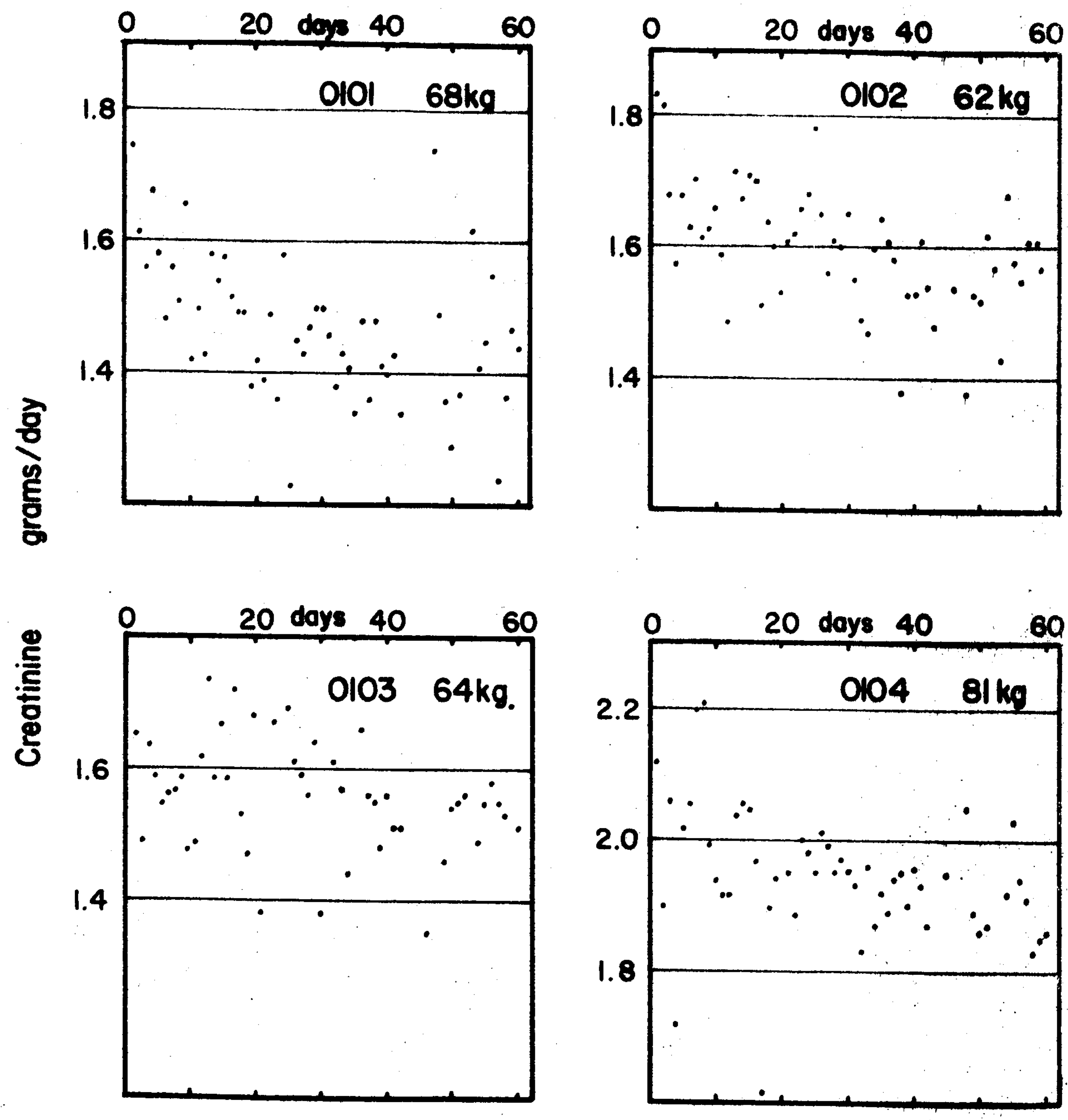


Fig. 4 Daily urinary creatinine excretion, Penthouse Study I

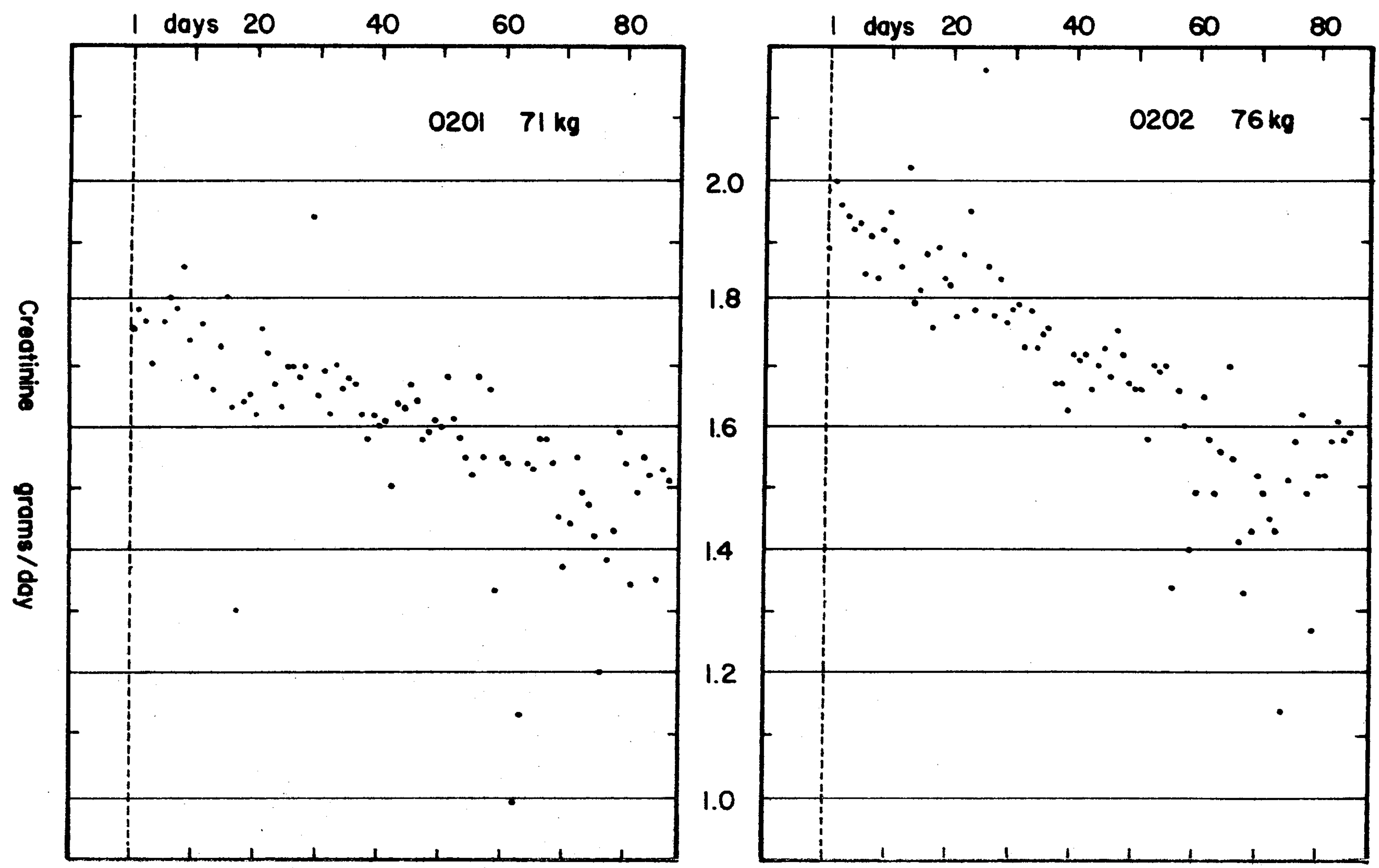


Fig. 5a Daily urinary creatinine excretion, Penthouse Study 2, Control subjects

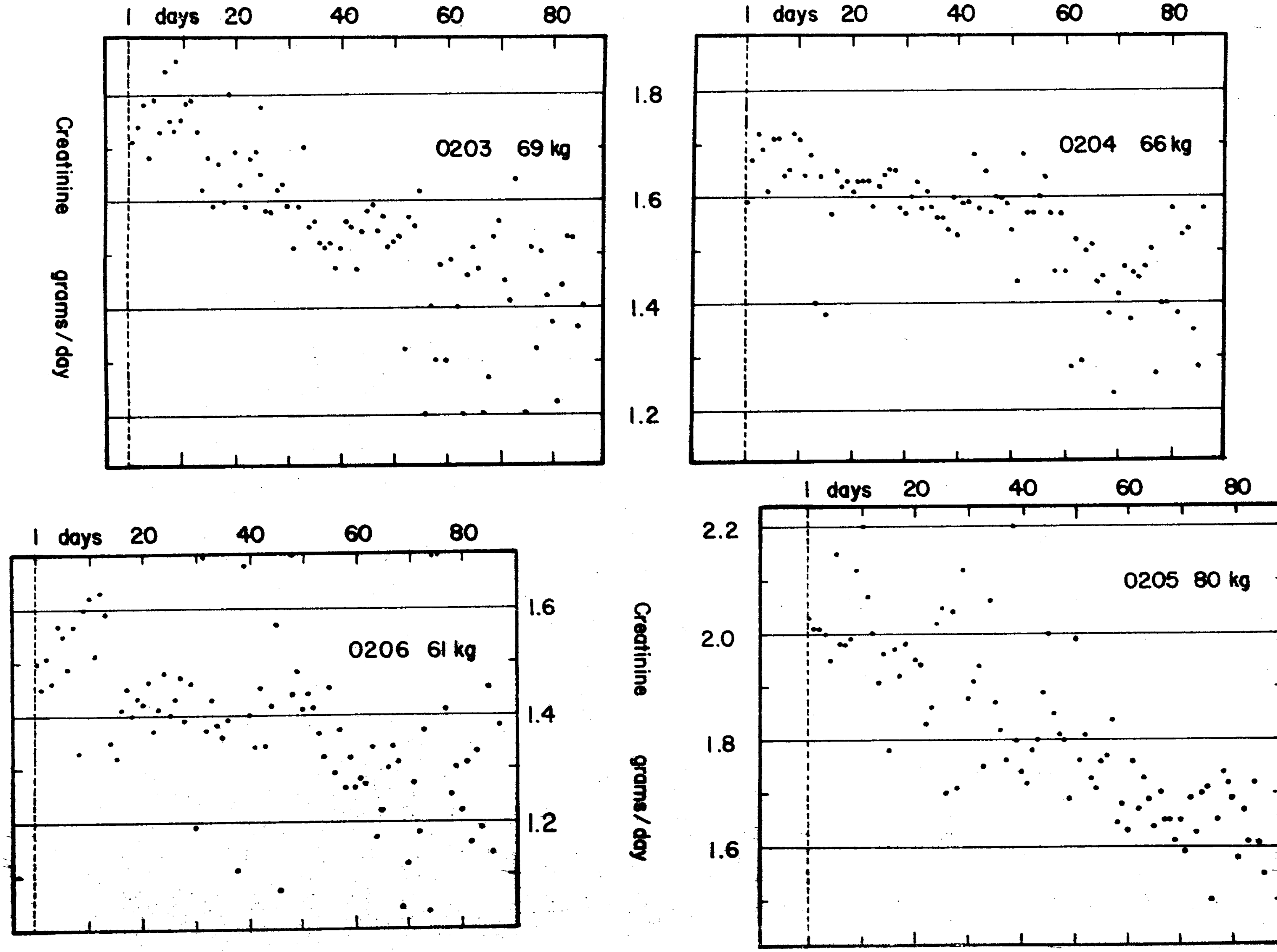


Fig. 5b Daily urinary creatinine excretion, Penthouse Study 2, subjects whose protein allowance varied

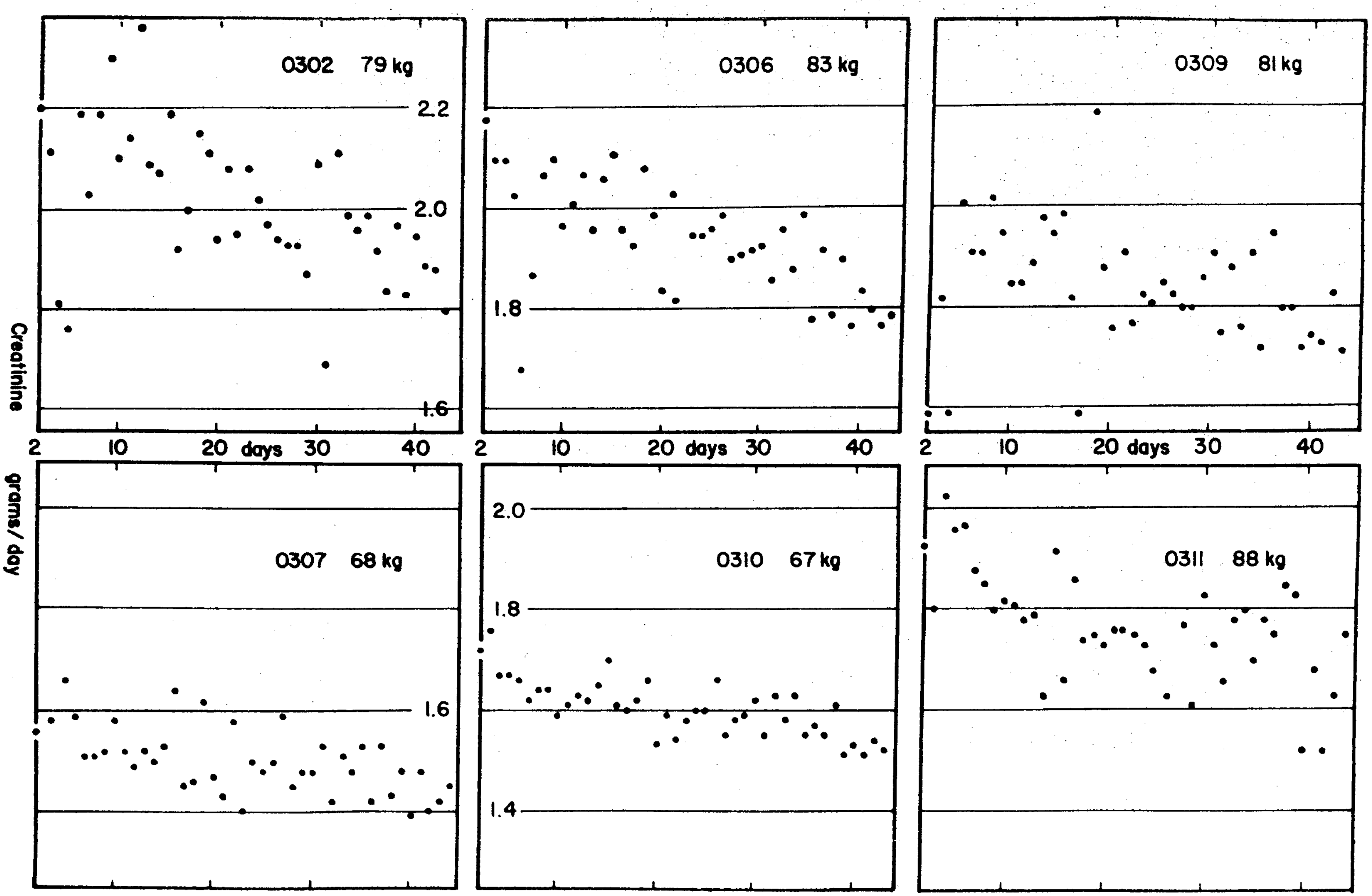


Fig. 6a Daily urinary creatinine excretion, Penthouse Study 3, formula subjects

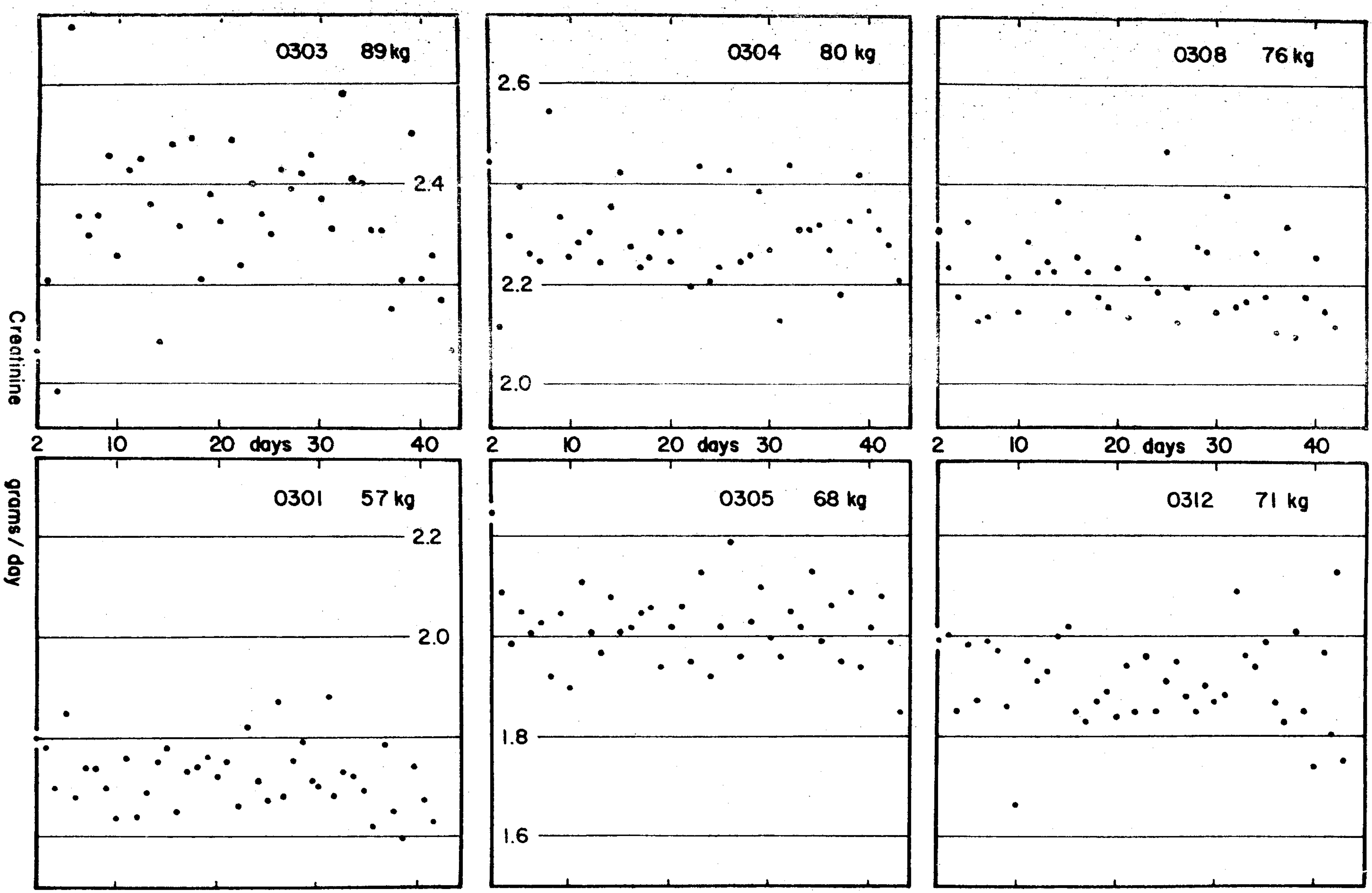


Fig. 6b Daily urinary creatinine excretion, Penthouse Study 3, Gemini subjects

URINARY CREATININE AND NITROGEN EXCRETION RELATED TO BODY WEIGHT,*
LAST 12 DAYS OF ZERO NITROGEN INTAKE PERIOD

		Creatinines Divided by Body Weight			Creatinines Divided by B. W.$^{.75}$**			Urinary Nitrogen Divided by B. W.$^{.75}$**		
Subject	Days	Mean	S.D.	Mean/S.D. Percent	Mean	S.D.	Mean/S.D. Percent	Mean	S.D.	Mean/S.D. Percent
0203	19-30	23.69	0.86	3.63	68.42	2.53	3.69	123.67	15.13	12.31
0204	55-66	22.53	1.63	7.20	64.30	7.43	11.56	93.75	8.78	9.37
0205	19-30	23.76	1.71	7.20	71.18	5.23	7.45	102.42	12.65	12.35
0206	19-29+	23.96	.72	3.01	66.52	1.50	2.25	115.64	6.23	5.39

*Except for percentages, figures represent mg/kg.
+Eleven days.
**Body weight to the .75 power.

C. Fluid Intake, Urine, and Feces

In all studies the subjects were allowed to drink the deionized water ad lib. Since the water administered by the dietitian in the formula or the beverage was constant, the self-administered water represents individual variations that are due either to differences between subjects or are reflections of changes in diet or other variables in the same subject.

As can be seen in Tables 21, 22, and 23 the variation in water intake is great from individual to individual. Although no clear-cut differences are seen, there is a suggestion that the self-administered water intake was decreased in the subjects during the periods of zero or low protein intake. This would be anticipated in part because of the decrease in the solute load occurring with the decrease in protein concentration. However, this alteration in solute load clearly is not the entire explanation because it is noted that in Study #3 the fluid intake of the formula subjects was larger than that of the Gemini group. This was true in spite of the fact that the solute load of the Gemini diet is larger than that of the formula because of higher protein and sodium chloride content of the latter. In fact, the total fluid intake of the formula group was higher than that of the Gemini group. This certainly suggests that thirst related to osmotic phenomenon is not the sole cause of water ingestion.

The urine volumes, specific gravity, and pH of Studies 1, 2, and 3 are shown in Tables 24, 25, and 26; the osmolarity of Study #3 is shown in Table 26. The volume of urine is related in great measure to the fluid intake. However, in Studies 1 and 2 the expected relationships between urine specific gravity and volume are not observed because of the artificial situation introduced by changes in urine specific gravity when protein is deleted from the diet. In Study #3 the close correlations between specific gravity and osmolarity and volume are noted. Here again, it is seen that the specific gravity and osmolarity of the formula diet is less than that on the Gemini diet, reflecting the increased water intake. As stated, the increased osmolarity and specific gravity in the Gemini diet is due to the increase of sodium chloride and protein in this diet as compared with the formula diet.

In Study #1 all subjects had a persistently alkaline urine ranging from between pH 7 and 8 except for the last 3 days of the Study on the recovery diet when the urine pH returned to acid. The persistently alkaline urine was probably due to a relative deficiency of chloride or other anions in the diet. This was changed in subsequent diets by addition of chloride, and the pH fell into an acid range.

WATER INTAKE, AD LIB*

Subject	Project Days	Dietary N_2(g)	Total H_2O(ml)	Number of Days	Average Daily H_2O Intake
0101	1-30, 52-60	12	27500	39	705
	31-45	0	9540	15	636
	46-51	12 R	3900	6	650
0102	1-60	12 C	36950	59	626
0103	1-30, 52-60	12	38200	39	979
	31-45	0	18400	15	1227
	46-51	12 R	7400	6	1233
0104	1-59	12 C	52495	59	890

*These figures do not include water administered by the dietitian in formula or beverage.

Table 22

WATER INTAKE, AD LIB*

Subject	Project Days	N_2 Intake	Total H_2O(ml)	Total Days	Mean H_2O(ml)	Number of Days (if less) H_2O was Actually Consumed*	Mean
0201	1-84	12 C	40659	84	484	77	528
0202	1-84	12 C	6000	84	71	46	130
0203	1-12	12	3600	12	300		
	13-30	0	600	18	33	2	300
	31-66	3	800	36	22	3	267
	67-84	12 R	2440	18	136	12	203
0204	1-12	12	4100	12	342	11	373
	13-30	3	9100	18	506	16	607
	31-48	12 R	12950	18	719		
	49-66	0	15000	18	833		
	67-84	12 R	13400	18	744		
0205	1-12	12	3605	12	300		
	13-30	0	2932	18	163		
	31-66	3	6530	36	181	32	204
	67-84	12 R	5840	18	324	17	344
0206	1-12	12	5675	12	473		
	13-30	0	4650	18	258	16	291
	31-48	12 R	3875	18	215	16	242
	49-66	3	5000	18	278	13	385
	67-84	12 R	4000	18	222	12	333

*These figures do not include liquid given by the dietitian in formula or beverage.

FLUID INTAKE, ml/day

	Formula	Gemini	
	42-day average	First 36 days	Last 6 days
Diet	1640	1363	--
Self-administered by subject	1756	525	1907
	1512	916	1904
	592	940	1902
	937	1375	1071
	784	956	2367
	1036	951	2520
Ave.	1103	944	1945
Total* ave.	2743	2307	1945

*Excluding preformed water provided by the dietary components (appr. 15 gm. average for the Gemini diet, and 37 gm. for the formula diet) and metabolic water (assuming 90% digestibility of the diets and no tissue destruction, appr. 313 ml. for the Gemini group and 327 ml. for the formula diet).

VOLUME, SPECIFIC GRAVITY, AND pH OF URINE

Subject	Period	Volume (ml)	Specific Gravity	pH
0101	1	1227	-----	---
	2	1009	-----	---
	3*	1091	1.017	7.9
	4	1341	1.016	7.3
0102	1	1129	-----	---
	2	961	-----	---
	3	908	1.023	7.6
	4	1042	1.021	7.1
0103	1	1362	-----	---
	2	1589	-----	---
	3*	1704	1.007	7.2
	4	1535	1.013	7.3
0104	1	958	-----	---
	2	1075	-----	---
	3	1090	1.018	7.4
	4	1153	1.020	7.1

*Zero nitrogen intake.

VOLUME, pH, AND SPECIFIC GRAVITY OF URINE

Subject	Volume ml/24 hrs	pH	Specific Gravity
0201	1312 ± 169	5.8	1.020 ± .003
0202	892 ± 180	5.8	1.025 ± .004
0203	1335 ± 194	5.9	1.022 ± .004
0204	1341 ± 82	6.4	1.011 ± .005
0205	1429 ± 169	5.7	1.027 ± .003
0206	1027 ± 229	6.3	1.019 ± .004

VOLUME, pH, SPECIFIC GRAVITY, AND
OSMOLARITY OF URINE*

Subject	Volume ml/24 hrs	pH	Specific gravity	Osmolarity mosm./liter
Gemini Group				
0301	1297±381	6.0	1.021±.004	826±163
0303	1300±306	6.0	1.021±.004	804±153
0304	1328±223	6.0	1.020±.003	776±112
0305	1763±338	6.1	1.015±.003	609±113
0308	1251±328	6.1	1.021±.005	874±197
0312	1294±313	6.1	1.020±.005	818±175
Average	1372±315	6.1	1.020±.004	784± 84
Formula Group				
0302	1961±708	6.3	1.012±.005	443±134
0306	1776±496	6.2	1.013±.004	486±130
0307	1223±257	6.1	1.017±.004	609±112
0309	1464±417	6.1	1.016±.005	569±142
0310	1658±240	6.1	1.013±.003	466± 64
0311	1613±351	6.0	1.013+.003	497± 85
Average	1616±412	6.1	1.014± .004	512± 58

*Each subject's entry is mean and standard deviation of 42 daily observations.

The excretion in the urine of the various nutrient elements is shown in Tables 27 through 31. Except in the case of calcium and magnesium, the amount of elements in the urine corresponds roughly to the amounts in the diet. The case of nitrogen is best discussed in the context of balance (see below). In Study #1 and, more particularly, Study #2 at the lower nitrogen intake (particularly at zero nitrogen intake) there was generally an increase in urinary phosphorus and potassium which represents in part the breakdown of intracellular protein associated with the negative protein balance.

What is most interesting in this data is the marked fall in urinary calcium and the smaller fall in urinary magnesium as the protein intake of the diet decreased. Since urinary excretion of these substances, particularly of calcium, is not considered usually to be related to content of the diet and hence absorption, this would indicate some significant change in calcium or bone metabolism associated with the lowering of nitrogen. This is certainly a significant finding and demonstrates an effect on calcium metabolism apparently not related to calcium intake, activity, or previously described hormonal processes. The possibility that this may be related in part to impaired absorption cannot be eliminated and is suggested by some of our data as seen in Tables 33 and 37. It is well known that certain amino acids enhance calcium absorption (e.g., lysine). However, the fecal excretion of calcium does not change sufficiently to support an absorption defect as the sole or principal explanation of this observed effect (see below). Likewise, on theoretical grounds it would appear unlikely that a decrease in dietary amino acids would be significant in view of the estimated large quantity of endogenous protein excreted into the gut and reabsorbed.

In Study #3 the nitrogen, phosphorus, chloride, and sodium excretion was higher and potassium and magnesium excretion lower in the Gemini group than in the formula group. Calcium excretion and intake did not differ significantly between these groups. In Table 32 are shown the hydroxyproline and catecholamine excretion of the subjects in Study #3. Hydroxyproline excretion of Gemini subjects was 50 percent higher than that of the formula group (63 vs 41 mg/day). Citrate excretion of Gemini subjects was less than 0.5 g/day, except for the case of subject 0303 who excreted an average of 1.13 g/day. During the experiment, this same subject had elevated blood levels of triglycerides, glucose, and glutamic pyramic transaminaise activity but no clinical evidence of pathological processes. Formula subjects excreted more citrate (0.7 g/day) but part of this may have been from the 5 g/day supplied in the diet. Catecholamine excretion averaged 31 to 44 mcg/day for all subjects irrespective of diet.

URINARY EXCRETION OF ELEMENTS
(g/day)

Subject	Period	Potassium	Sodium	Calcium	Magnesium	Phosphorus
0101	I	2.65	3.55	.255	.095	.450
	II	3.09	3.10	.159	.107	.680
	III*	3.44	2.93	.123	.160	.780
	IV	2.74	3.18	.141	.136	.590
	Average	2.98	3.19	.170	.125	.625
0102	I	2.84	3.89	.168	.198	.587
	II	2.79	3.12	.094	.172	.713
	III	3.04	2.48	.036	.175	.983
	IV	2.75	3.14	.080	.207	.586
	Average	2.85	3.16	.095	.188	.718
0103	I	2.59	3.57	.145	.146	.490
	II	2.80	3.24	.083	.136	.730
	III*	3.01	2.57	.035	.163	.980
	IV	2.71	3.15	.090	.181	.600
	Average	2.78	3.13	.088	.157	.700
0104	I	2.53	3.33	.285	.238	.550
	II	3.13	2.75	.150	.209	.857
	III	3.49	2.66	.136	.248	.791
	IV	2.90	3.78	.155	.229	.795
	Average	3.01	2.88	.182	.231	.750

*Zero nitrogen intake. For nitrogen, see Table 87.

Table 28

URINARY EXCRETION OF ELEMENTS AVERAGED BY SUBJECT,
g/day, BY TREATMENT PERIOD

Subject	Experiment Days	Phosphorus	Chloride	Sodium	Potassium	Calcium	Magnesium
0201	1-84	.911 ± .115	3.82 ± .610	2.81 ± .455	2.28 ± 1.80	.204 ± .173	.271 ± .022
0202	1-84	.854 ± .105	3.83 ± .463	2.83 ± .360	2.81 ± .573	.262 ± .054	.283 ± .031
0203	1-12	.855 ± .035	4.54 ± .828	2.92 ± .275	3.14 ± .629	.184 ± .124	.232 ± .060
	13-30**	.944 ± .051	3.76 ± .336	2.76 ± .212	3.07 ± .312	.131 ± .017	.160 ± .017
	31-66	.814 ± .125	3.66 ± .620	2.59 ± .242	2.85 ± .278	.234 ± .137	.164 ± .029
	67-84	.607 ± .036	3.68 ± .492	2.72 ± .276	2.73 ± .272	.174 ± .018	1.74 ± .011
0204	1-12	.805 ± .075	4.49 ± .249	3.20 ± .423	2.93 ± .183	.107 ± .013	.216 ± .030
	13-30*	.94 ± .123	3.80 ± .336	3.01 ± .634	2.88 ± .078	.075 ± .010	.246 ± .029
	31-48	.73 ± .066	3.78 ± .178	2.84 ± .211	2.65 ± .243	.126 ± .025	.231 ± .016
	49-66*	1.09 ± .139	3.66 ± .382	2.70 ± .333	3.26 ± .283	.074 ± .010	.225 ± .011
	67-84	.678 ± .086	3.74 ± .261	2.78 ± .185	2.76 ± .137	.123 ± .006	.223 ± .019
0205	1-12	1.025 ± .032	3.56 ± .717	2.42 ± .428	3.44 ± .355	.148 ± .014	.271 ± .025
	13-30**	1.130 ± .028	2.70 ± .356	2.45 ± .537	2.59 ± .417	.116 ± .007	.287 ± .017
	31-66*	1.050 ± .068	2.74 ± .371	2.06 ± .295	3.03 ± .315	.151 ± .013	.284 ± .049
	67-84	.750 ± .067	2.62 ± .342	1.99 ± .281	2.61 ± .181	.179 ± .014	.268 ± .029
0206	1-12	.892 ± .043	4.40 ± .252	3.07 ± .269	2.96 ± .179	.201 ± .200	.242 ± .044
	13-30**	.98 ± .156	3.76 ± .061	3.17 ± .534	2.86 ± .106	.108 ± .027	.203 ± .028
	31-48	.62 ± .136	3.50 ± .348	2.67 ± .180	2.69 ± .220	.237 ± .047	.208 ± .013
	49-66*	.885 ± .022	3.62 ± .293	2.59 ± .208	2.96 ± .266	.146 ± .023	.226 ± .023
	67-84	.730 ± .103	3.34 ± .509	2.57 ± .321	2.78 ± .169	.183 ± .021	.243 ± .023

* 3 g nitrogen intake.

** "Zero" g nitrogen intake.

URINARY EXCRETION OF ELEMENTS
g/day, BY METABOLIC PERIOD

Subject	Period	Treat-ment	Nitrogen	Calcium	Sodium	Potassium	Phosphorus	Magnesium
0201	I	A12	11.11	.181	3.06	3.11	.99	.265
	II	A12	10.12	.182	2.71	2.85	.86	.286
	III	A12	10.96	.187	2.86	2.82	.88	.266
	IV	A12	9.78	.231	2.70	2.78	.88	.260
	V	A12	10.49	.234	2.81	2.99	.92	.276
0202	I	A12	12.02	.310	2.91	3.24	1.01	.248
	II	A12	10.85	.338	2.91	2.95	.916	.312
	III	A12	9.99	.262	2.72	2.72	.805	.280
	IV	A12	9.82	.229	2.80	2.96	.809	.277
	V	A12	9.67	.203	2.68	2.82	.767	.265
0203	I	A12	12.01	.184	2.92	3.14	.854	.233
	II	A0	3.65	.131	2.76	3.07	.946	.161
	III	A3	3.38	.159	2.60	2.90	.835	.165
	IV	A3	2.78	.149	2.58	2.79	.792	.164
	V	A12	8.42	.175	2.63	2.73	.606	.188
0204	I	A12	9.78	.107	3.20	2.93	.800	.224
	II	A3	3.64	.075	3.01	2.88	1.05	.248
	III	A12	8.16	.126	2.85	2.65	.737	.230
	IV	A0	2.67	.074	2.70	3.26	1.07	.225
	V	A12	7.11	.123	2.78	2.74	.678	.223
0205	I	A12	11.51	.147	2.42	3.43	1.02	.271
	II	A0	3.49	.116	2.45	2.59	1.13	.287
	III	A3	3.46	.146	2.12	3.08	1.06	.283
	IV	A3	2.86	.156	1.91	3.04	1.03	.286
	V	A12	6.82	.179	1.99	2.61	.750	.268
0206	I	A12	10.06	.201	3.07	2.96	.892	.243
	II	A0	2.94	.108	3.17	2.86	.978	.203
	III	A12	7.26	.237	2.67	2.69	.621	.208
	IV	A3	3.60	.146	2.60	2.96	.885	.227
	V	A12	8.80	.183	2.57	2.78	.730	.243

Table 30

URINARY EXCRETION OF ELEMENTS, g/day
AVERAGED BY PERIODS OF DIETARY TREATMENT

Diet	Nitrogen	Potassium	Chloride	Sodium	Phosphorus	Calcium	Magnesium
12 g Nitrogen (324 man/days)	9.59±1.99	2.84±.401	3.76±.635	2.76±.490	.82±.139	.201±.105	.255±.062
3 g Nitrogen (108 man/days)	3.25±.787	2.93±.312	3.37±.613	2.48±.505	.92±.148	.165	.228±.060
"0" Nitrogen (72 man/days)	3.19±1.31	2.94±.410	3.47±.545	2.77±.498	1.04±.154	.105±.011	.219±.049

Table 31

URINARY EXCRETION OF ELEMENTS (g/day)

(Mean and standard deviation of collections pooled by 6-day periods)

S	N	Nitrogen	Phosphorus	Chloride	Sodium	Potassium	Calcium	Magnesium
Gemini Group								
0301	7	13.46±0.39	1.17±.04	7.54±.39	5.40±.39	2.25±.14	.223±.046	.112±.026
0303	6	13.62±1.16	1.08±.13	7.13±.43	4.92±.46	2.26±.24	.155±.042	.133±.030
0304	7	14.92±0.48	1.26±.11	6.98±.47	4.94±.45	2.36±.26	.147±.046	.144±.037
0305	7	14.89±0.44	1.25±.09	7.45±.29	5.22±.33	2.33±.18	.268±.067	.089±.040
0308	7	14.71±0.17	1.12±.14	7.13±.47	4.85±.29	2.09±.19	.210±.010	.120±.030
0312	7	14.19±0.49	1.16±.12	7.32±.30	5.12±.29	2.12±.20	.201±.024	.109±.044
Ave.		14.30	1.17	7.26	5.08	2.24	.201	.118
Formula Group								
0302	5	12.02±0.86	0.99±.16	3.78±.40	3.03±.34	3.18±.48	.261±.010	.223±.017
0306	7	12.50±0.87	1.08±.15	3.76±.33	2.88±.29	3.32±.55	.244±.021	.200±.024
0307	7	10.20±0.39	0.96±.12	3.91±.18	3.01±.14	3.05±.59	.[illegible]35±.025	.200±.021
0309	6	11.74±0.59	0.93±.13	3.63±.35	2.80±.17	3.43±.48	.137±.008	.231±.001
0310	7	10.71±0.85	0.81±.10	3.97±.45	3.00±.36	3.24±.39	.159±.024	.202±.017
0311	7	11.75±0.78	0.99±.16	3.86±.35	2.77±.40	3.21±.42	.222±.020	.239±.020
Ave.		11.49	0.96	3.82	2.92	3.24	.201	.216

HYDROXYPROLINE, CITRATE, AND CATECHOLAMINE CONTENT OF URINE

Subject	Hydroxyproline	Citrate	Catecholamines
	mg/day	g /day	mcg/day
Gemini Group			
0301	59± 8	0.23±.05	33± 4
0303	41± 1	1.13±.16	39± 8
0304	67±11	0.33±.03	37± 6
0305	83±13	0.39±.03	32± 5
0308	72±12	0.37±.09	42± 9
0312	56± 5	0.46±.30	44±10
Average	63±13	0.48±.30	38± 2
Formula Group			
0302	39± 2	0.64±.08	38±10
0306	50± 8	0.61±.10	36± 6
0307	49± 8	0.58±.10	31± 9
0309	52± 7	1.00±.22	40± 8
0310	27± 3	0.79±.08	35±13
0311	27± 4	0.64±.13	41±13
Average	41± 1	0.71± .15	37± 3

* Each subject's entry is the mean and deviation of seven samples consisting of pooled aliquots of six successive 24-hour collections of urine, except for subject's 0303 and 0309 (N = 6) and 0302 (N = 5).

An interesting temporal variation in excretion patterns occurred. As seen in Figure 7 excretion rose slightly during the second metabolic period, fell sharply during the 2 successive periods, and rose again reaching a level above the initial value during the last period. All subjects showed this pattern, although to varying degrees. The fall in apparent adrenal medullary activity coincides with the midexperimental "slump" described by the psychologists and socio-legal investigators in the project and described below. The subsequent rise may indicate some increased emotional reaction to the anticipation of the end of confinement.

Tables 33 through 41 show fecal weight, frequency, and the fecal excretion of elements in the 3 studies reported. The subjects on the formula diet showed a "less than normal" fecal mass during the course of the experiment. This might be expected since the diet is extremely low in residue. Although at times the subjects did complain of some soft stools, it is clear that there was no excessive diarrhea or fluid loss in the stools. Figure 8 shows weight of feces in Study #3.

In Study #2 it is seen that as the nitrogen in the diet decreases the weight of the stool tends to increase. This was probably due to some increased motility with fluid loss due to the higher sugar content of the diet. This change, however, was not observed in Study #1. There was no significant effect of this change in wet weight on the dry weight of the feces.

In Study #3 it is seen that the Gemini diet proved to be less well absorbed than was the formula diet and resulted in more frequent passage of stools of larger volume. The average frequency was 10 percent greater for the Gemini group, but with both diets the men had none or only one movement a day 80 percent of the time. The wet weight of the stools was 60 percent greater in the Gemini group, and the dry weight almost 3 times as large as with the formula diet. The daily average fecal weights were not markedly different between given individuals receiving the same diet. However, the weights of the individual stools showed considerable variation.

The fecal excretion of the elements in Studies 1 and 2 revealed no significant change in nitrogen in spite of alterations in dietary protein. The individuals receiving zero nitrogen showed excretion figures which were essentially unchanged from that of the 12 g nitrogen intake. This signifies, therefore, that the protein was of high digestibility.

The fecal phosphorus, sodium, and potassium showed no change, and there was no significant change noted in calcium. However, the calcium fecal excretion at zero nitrogen appeared to be higher than that of 12 g, although there had been some calcium excretion decrease at the 3 g nitrogen intake compared to the 12 g intake.

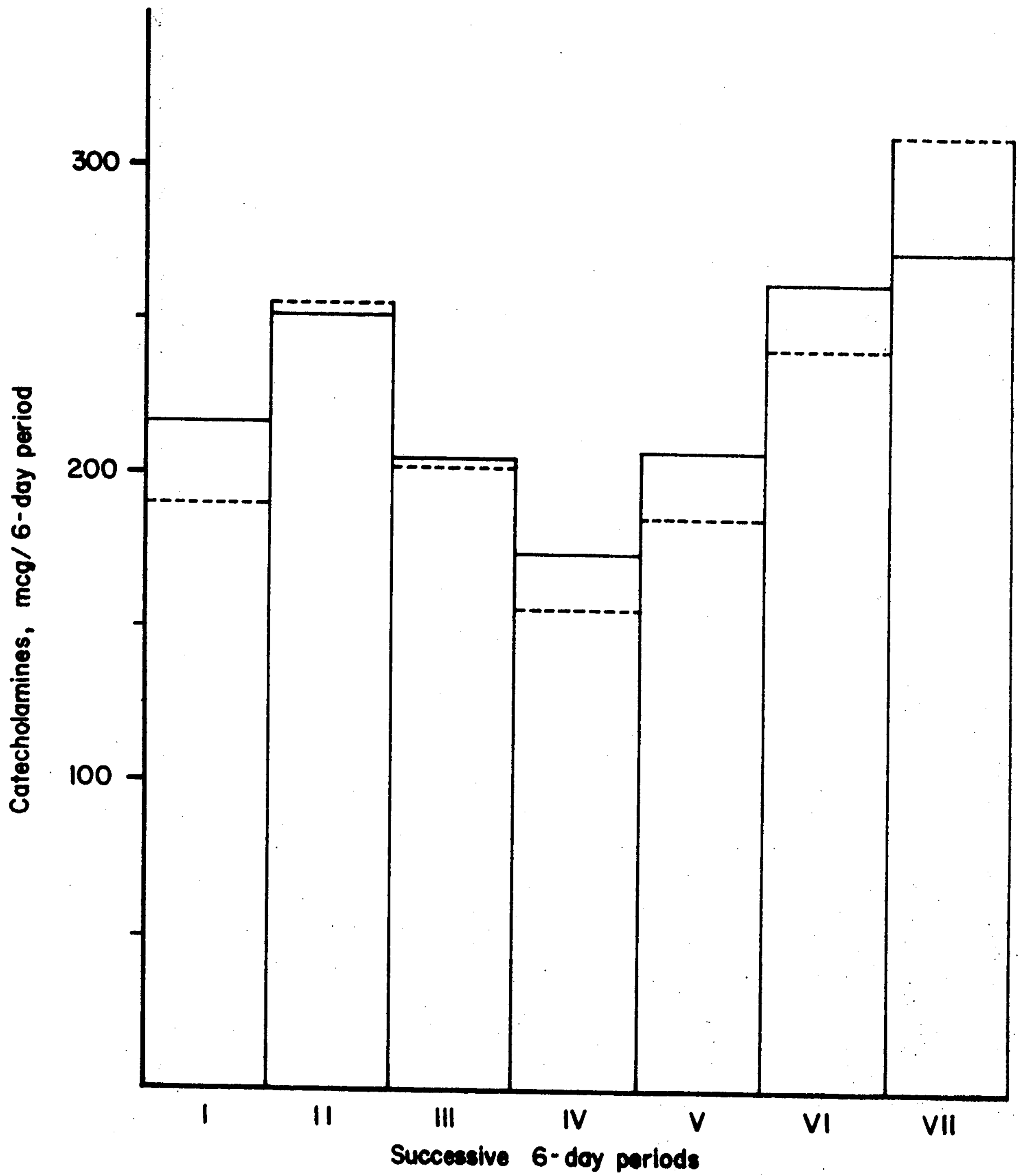


Fig. 7 Urinary catecholamines, mcg/six day period, Penthouse Study 3

Gemini subjects ———— Formula subjects ---------

MINERAL INTAKE* AND FECAL EXCRETION+ AVERAGED BY METABOLIC PERIOD, g/day

Period	Subject	Intake	Excre-tion	Intake	Excre-tion	Intake	Excre-tion	Intake	Excre-tion	Intake	Excre-tion
I	0101	3.614	0.012	3.418	0.199	0.861	0.708	0.534	0.249	1.021	0.400
	0102	↓	0.030	↓	0.198	↓	0.758	↓	0.468	↓	0.410
	0103		0.056		0.389		1.143		0.337		0.642
	0104		0.005		0.144		0.863		0.200		0.371
II	0101	3.156	0.040	2.756	0.161	2.041	0.968	0.474	0.250	1.277	0.506
	0102	↓	0.026	↓	0.192	↓	0.938	↓	0.360	↓	0.586
	0103		0.058		0.257		1.105		0.295		0.596
	0104		0.005		0.102		0.920		0.215		0.422
III	0101**	2.783	0.039	3.251	0.149	1.735	1.084	0.474	0.243	1.404	0.595
	0102	3.152	0.017	2.756	0.182	2.041	0.918	↓	0.329	1.277	0.616
	0103**	2.784	0.036	3.251	0.212	1.735	0.952		0.248	1.404	0.561
	0104	3.152	0.003	2.756	0.082	2.041	0.845		0.222	1.277	0.611
V	0101	3.162	0.526	2.796	0.297	1.236	1.191	0.443	0.239	1.294	0.638
	0102	3.284	0.048	2.631	0.343	1.443	1.059	↓	0.315	1.252	0.665
	0103	3.162	0.020	2.796	0.267	1.236	1.125		0.259	1.294	0.636
	0104	3.284	0.006	2.631	0.111	1.443	1.057		0.233	1.252	0.577

*Intakes based on averages.

+Fecal excretion from computer read-out sheet.

**Zero nitrogen intake.

FECAL WEIGHTS
(in grams/24 hours)

Subject	Test Periods I			II			III			IV			Total
Wet Weights													
0101	167	49	76	76	80	75	75*	67*	72*	72	84	137	86 ± 31
0102	72	78	116	116	71	66	66	67	102	70	80	48	79 ± 21
0103	176	70	108	108	58	87	87*	46*	68*	25	61	83	81 ± 38
0104	99	65	73	73	48	39	39	38	37	89	38	24	55 ± 23
Dry Weights													
0101	13	15	24	24	20	15	15*	13*	24*	15	19	27	19 ± 3
0102	25	15	22	22	18	18	18	19	18	18	19	27	20 ± 3
0103	44	14	29	29	15	22	22*	14*	19*	8	18	23	21 ± 3
0104	14	17	23	23	14	15	15	14	14	23	12	14	16 ± 6

*Zero nitrogen intake.

AVERAGE DAILY FECAL WEIGHTS
IN GRAMS ACCORDING TO DIETARY NITROGEN

	Wet Weight	Dry Weight
12 grams Nitrogen intake (N = 324)*	73 ± 15	18 ± 3
3 grams Nitrogen intake (N = 108)*	81 ± 18	17 ± 4
"0" Nitrogen intake (N = 72)*	93 ± 22	17 ± 8

*These calculations are based on weighted averages and the units are man/days.

FECAL WEIGHTS (in grams/24 hours)

Subject	Days	Daily Nitrogen Intake (grams)	Wet Weight	Dry Weight
0201	1-84	12	68	19
0202	1-84	12	91	21
0203	1-12	12	65	17
	13-30	0	130	19
	31-66	3	105	16
	67-84	12	102	19
0204	1-12	12	41	14
	13-30	3	61	17
	31-48	12	64	15
	49-66	0	82	18
	67-84	12	77	18
0205	1-12	12	32	12
	13-30	0	74	18
	31-66	3	67	18
	67-84	12	47	15
0206	1-12	12	49	14
	13-30	0	86	20
	31-48	12	60	13
	49-66	3	81	19
	67-84	12	74	15

FECAL EXCRETION OF ELEMENTS,
g/day, BY METABOLIC PERIOD

Subject	Period	Treat-ment	Nitrogen	Calcium	Sodium	Potassium	Phosphorus	Magnesium
0201	I	A12	1.24	.883	.008	.113	.588	.304
	II	A12	1.09	.623	.006	.108	.443	.238
	III	A12	.83	.562	.008	.084	.408	.229
	IV	A12	.97	.638	.005	.083	.429	.250
	V	A12	1.39	.783	.021	.177	.516	.300
0202	I	A12	1.42	.774	.029	.143	.623	.236
	II	A12	1.57	.806	.025	.154	.653	.253
	III	A12	1.56	.804	.034	.171	.680	.263
	IV	A12	1.37	.656	.023	.181	.532	.229
	V	A12	1.86	.809	.056	.222	.706	.293
0203	I	A12	1.11	.757	.037	.203	.666	.335
	II	AO	1.07	.868	.069	.252	.653	.337
	III	A3	1.12	.889	.047	.228	.714	.349
	IV	A3	1.26	.936	.047	.259	.707	.362
	V	A12	1.26	.834	.024	.308	.768	.365
0204	I	A12	.86	.683	.009	.104	.516	.238
	II	A3	.98	.853	.025	.107	.551	.274
	III	A12	.92	.834	.006	.148	.526	.265
	IV	AO	.89	.781	.022	.108	.430	.267
	V	A12	1.33	.889	.013	.167	.634	.327
0205	I	A12	.70	.602	.004	.062	.444	.188
	II	AO	1.05	.968	.006	.107	.493	.251
	III	A3	1.03	.863	.004	.106	.483	.231
	IV	A3	1.11	.832	.006	.122	.328	.233
	V	A12	.80	.650	.004	.071	.421	.198
0206	I	A12	.78	.683	.008	.093	.520	.238
	II	AO	1.06	1.033	.043	.193	.738	.356
	III	A12	.80	.644	.011	.120	.513	.233
	IV	A3	.95	.891	.006	.153	.658	.316
	V	A12	.84	.667	.008	.127	.556	.269

FECAL EXCRETION OF ELEMENTS AVERAGED BY SUBJECT,
g/day, BY TREATMENT PERIOD

Subject	Experiment Days	Phosphorus	Sodium	Potassium	Calcium	Magnesium
0201	1-84	.47 ± .14	.01 ± .01	.11 ± .05	.68(.31-1.12)	.20 ± .08
0202	1-84	.64 ± .13	.03 ± .02	.16 ± .06	.77(.51-1.04)	.26 ± .05
0203	1-12	.66(.55-.78)	.03(.03-.04)	.20(.19-.22)	.75(.67-.84)	.33(.28-.39)
	13-30**	.65(.58-.73)	.07(.02-.11)	.25(.16-.31)	.89(.79-.96)	.34(.27-.38)
	31-66*	.71 ± .02	.05 ± .03	.24 ± .06	.92(.83-1.00)	.35 ± .02
	67-84	.76(.50-1.02)	.02(.02-.03)	.31(.24-.42)	.83(.56-1.09)	.36(.25-.49)
0204	1-12	.51(.50-.52)	.01 ± .01	.10(.08-.13)	.68(.61-.76)	.24(.23-.24)
	13-30*	.55(.44-.70)	.02(.01-.04)	.11(.09-.11)	.85(.69-1.07)	.27(.21-.35)
	31-48	.52(.44-.65)	.02(.00-.01)	.09(.06-.11)	.72(.61-.91)	.26(.21-.33)
	49-66*	.43(.29-.54)	.02(.01-.04)	.11 ± .00	.78(.55-1.00)	.26(.20-.31)
	67-84	.63(.52-.76)	.01(.00-.03)	.17(.11-.20)	.89(.78-1.00)	.32(.28-.38)
	1-12 + 31-48 + 67-84#	.56 ± .10	.01 ± .01	.12 ± .04	.78(.61-1.00)	.28 ± .05
0205	1-12	.44(.29-.59)	.00(.00-.01)	.06(.05-.08)	.60(.42-.79)	.19(.12-.26)
	13-30**	.49(.41-.60)	.01(.00-.01)	.11(.10-.11)	.97(.78-1.15)	.25(.21-.31)
	31-66*	.46 ± .07	.00(.00-.01)	.11 ± .02	.85(.65-1.04)	.23 ± .03
	67-84	.42(.41-.43)	.00 ± .00	.07(.06-.08)	.65(.62-.68)	.20(.19-.21)
0206	1-12	.52(.45-.59)	.01 ± .01	.11(.08-.14)	.68(.64-.72)	.24(.21-.27)
	13-30**	.73(.70-.77)	.04(.02-.08)	.19(.15-.25)	1.03(.97-1.13)	.35(.34-.37)
	31-48	.51(.40-.63)	.01 ± .01	.12(.11-.12)	.64(.50-.82)	.23(.18-.29)
	49-66*	.65(.60-.69)	.02(.01-.02)	.15(.12-.17)	.89(.88-.91)	.31(.30-.34)
	67-84	.55(.52-.61)	.02(.01-.02)	.10(.01-.17)	.67(.63-.71)	.27(.25-.28)
	1-12 + 31-48 + 67-84#	.53 ± .08	.01 ± .00	.11 ± .04	.66(.50-.82)	.25 ± .04

* 3 g/day nitrogen intake.

** "Zero" nitrogen intake.

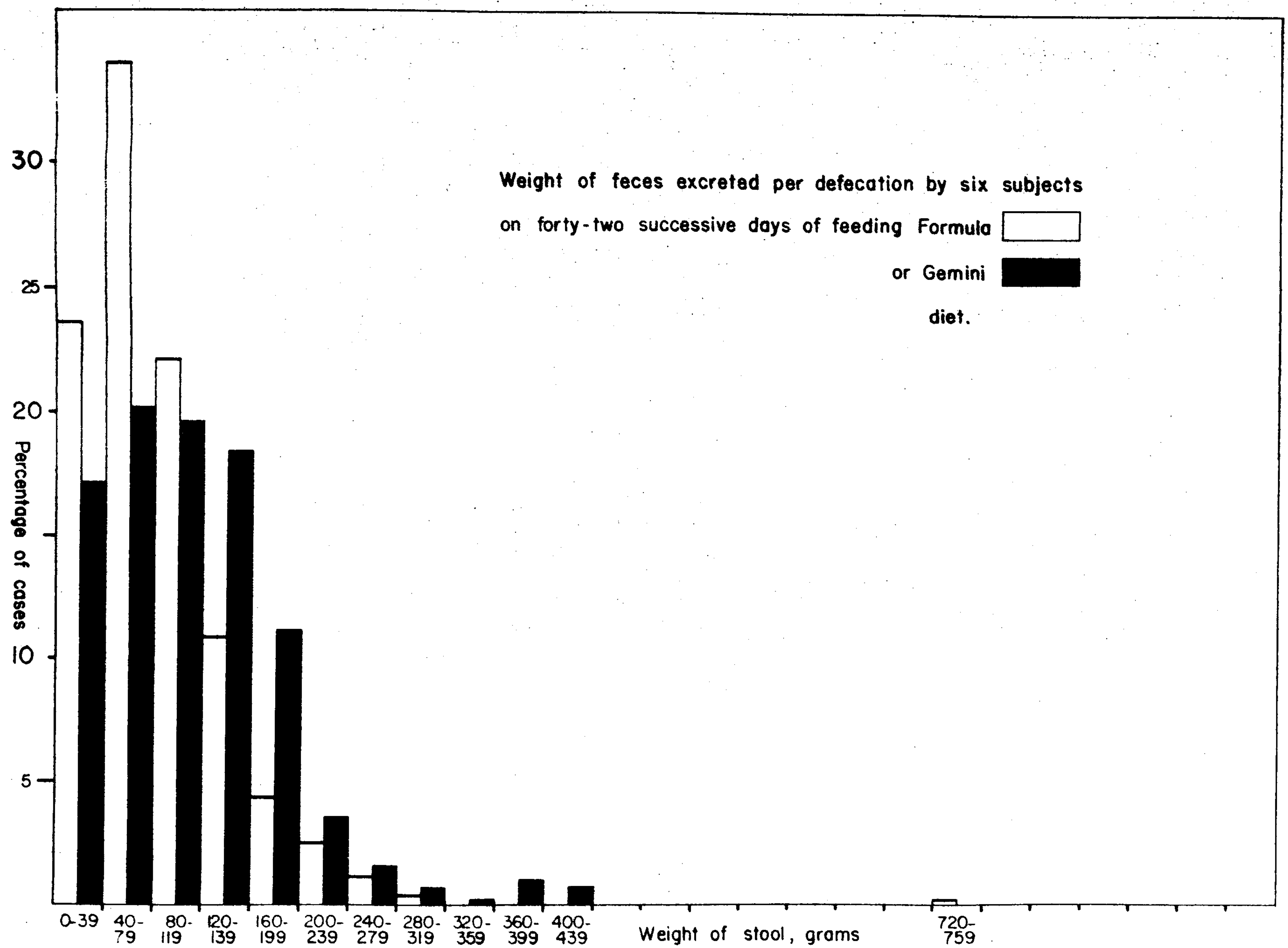
\# Combined high nitrogen intake periods.

FECAL EXCRETION OF ELEMENTS, g/day
AVERAGED BY DIETARY TREATMENT

Diet	Nitrogen	Phosphorus	Sodium	Potassium	Calcium
12 g nitrogen/ day (N = 324 man/days)	1.15 ± .40	.55 ± .16	.02 ± .01	.10 ± .07	.72 ± .40
3 g nitrogen/ day (N = 108 man/days)	1.07 ± .19	.59 ± .13	.02 ± .02	.10 ± .04	.88 ± .27
0 g nitrogen/ day (N = 72 man/days)	1.02 ± .12	.58 ± .14	.04 ± .03	.10 ± .07	.91 ± .36

STOOL FREQUENCY AND WEIGHT

Subject	Ave.No. per day	Bowel Movements % of test days with frequency 0	1	2	3	4	Weight of feces, g./day Wet	Dry
Gemini Diet								
0301	1.07	0	93	7	0	0	140	46
0303	0.98	21	60	19	0	0	153	43
0304	1.50	14	36	38	10	2	117	38
0305	1.21	7	67	24	2	0	119	35
0308	0.74	29	69	2	0	0	157	44
0312	1.10	7	76	17	0	0	140	41
Ave.	1.10	13	67	18	2	0.03	138±17	41±5
Formula Diet								
0302	0.90	26	60	12	2	0	81	12
0306	0.98	24	60	12	5	0	113	17
0307	1.57	0	52	38	10	0	126	18
0309	0.26	74	26	0	0	0	52	14
0310	1.42	0	60	38	2	0	75	15
0311	0.81	21	76	2	0	0	69	14
Ave.	0.99	24	56	17	3	0	86±25	15±2



Weight of feces excreted per defecation by six subjects
on forty-two successive days of feeding Formula
or Gemini
diet.
30
25
20
Percentage of cases
10
5
0-39
40-79
80-119
120-139
160-199
200-239
240-279
280-319
320-359
360-399
400-439
Weight of stool, grams
720-759

Fig. 8

FECAL EXCRETION OF ELEMENTS, g/day

(Mean and standard deviation of collections pooled by 6-day periods)

Subject	Nitrogen	Phosphorus	Chloride	Sodium	Potassium	Calcium	Magnesium
Gemini Group							
0301	1.99±.12	0.37±.11	0.01±.01	0.08±.04	0.45±.05	0.582±.047	0.147±.044
0303	2.37±.63	0.46±.14	0.03±.02	0.13±.05	0.61±.16	0.664±.212	0.127±.054
0304	1.67±.07	0.34±.07	0.02±.01	0.04±.01	0.55±.08	0.736±.083	0.126±.040
0305	1.56±.02	0.36±.06	0.02±.02	0.12±.04	0.49±.08	0.658±.101	0.188±.057
0308	1.69±.31	0.48±.06	0.05±.02	0.13±.04	0.82±.10	0.674±.107	0.168±.058
0312	1.96±.13	0.37±.04	0.03±.01	0.10±.00	0.63±.07	0.581±.122	0.152±.026
Average	1.87	0.40	0.03	0.10	0.59	0.649	0.151
% of intake	12	27	0.4	2	21	80	66
Formula Group							
0302	0.74±.27	0.37±.15	0.04±.03	0.03±.04	0.12±.05	0.481±.190	0.270±.106
0306	1.13±.38	0.32±.14	0.08±.04	0.06±.00	0.13±.02	0.534±.211	0.309±.136
0307	1.27±.22	0.35±.20	0.06±.03	0.04±.06	0.18±.06	0.591±.209	0.340±.093
0309	0.79±.29	0.42±.18	0.01±.01	0.01±.00	0.08±.03	0.658±.241	0.289±.117
0310	1.18±.25	0.51±.14	0.03±.01	0..02±.01	0.13±.05	0.692±.173	0.346±.065
0311	0.84±.21	0.38±.04	0.03±.02	0.03±.06	0.10±.04	0.577±.048	0.294±.039
Average	0.99	0.39	0.04	0.03	0.12	0.589	0.308
% of intake	8	29	1	1	4	72	62

No consistent pattern of fecal excretion of calcium is seen, and therefore this data does not help to explain the depression of urinary calcium excretion seen when the protein intake of the diet was decreased.

There does appear to be a progressive increase in fecal magnesium excretion as the protein intake decreases. This, therefore, would tend to explain at least in part the slight decrease in urinary magnesium observed with the decrease in protein intake.

In Study #3 the fecal nitrogen on the formula diet was similar to that noted in Studies 1 and 2. The fecal output of nitrogen, potassium, and calcium was higher in the Gemini group than in the formula group both in terms of absolute amount and percentage of intake. Fecal nitrogen was 12 percent of Gemini dietary and 8 percent of formula nitrogen. Comparable values for calcium were 80 percent and 72 percent; for potassium, 21 percent and 4 percent. It should be pointed out, however, that the calculation of 8 percent of diet nitrogenous "loss" on the formula diet is an artifact because the actual amount of nitrogen lost is the same as the endogenous nitrogen excretion which was noted at zero protein intake. The slightly poorer absorption of the Gemini nitrogen than that of egg albumin is probably due to processing of the foods and to the presence of some naturally less absorbable protein, such as legumes and other plant materials.

D. Integumentary Losses

The nitrogen excretion values from the skin plus sweat are given in Tables 42, 43, 44, and 45. Dermal excretion of nitrogen was significantly higher when the subject was on the control diet, either formula or Gemini, than when he was consuming either the zero- or low-protein diet. Only subject 0206 did not show a significant difference. It therefore appeared that the quantity of protein ingested does have an influence on the amount of nitrogen found in dermal excretion.

The temperature during the course of the experiments ranged from 32 to 83° F. These temperatures are below the alleged critical temperature of 88 to 90° F. when visible sweating is said to begin. The dermal excretion contained an average of 119 mg of nitrogen per day, with a range of 48 to 211 mg, for subjects on the control diet. These results are lower than values reported by other investigators, particularly Mitchell and Hamilton (Reference 5) who have reported daily nitrogen losses ranging between 254 and 360 mg/day.

The experimental design of the other investigators, however, was slightly different from ours. Our lower estimates for nitrogen excretion may be explained on the assumptions that our subjects were completely acclimated during the Studies, that the Studies were of long duration, and that the only moisture lost from the skin was that of insensible perspiration. However, we do realize that complete collection of losses was not obtained by the methods that we employ. The fact that with the underclothing we used the subjects' necks, heads, lower arms, hands, and feet were not covered during the collection period explains in part at least the lower values we obtained.

It was necessary that these areas not be covered because the subjects wore their sweat collection outfits for 3 to 6 days and during this time they participated in a variety of other tests. More complete covering would have interfered with these tests and possibly promoted the sweating mechanism during much of the studies. Furthermore, although attempts were made to have the subjects keep their undersuits buttoned at all times, it was observed that there was a tendency to unbotton the front of the suits and to bare the chest during some portions of the experiments.

In view of the alterations in nitrogen loss by the skin in relation to diet, it was important to determine if possible which constituent of the sweat had been altered by the dietary manipulations. The nitrogenous constituents of the sweat are urea creatinine, creatine, ammonia, and amino acid. The concentration of the

AVERAGE DAILY DERMAL NITROGEN LOSS

	Temp. Range 32-60°F.		Temp. Range (F) 35-63°F.		Temp. Range (F) 39-60°F.	
Subject	Diet	Nitrogen mg/day	Diet	Nitrogen mg/day	Diet	Nitrogen mg/day
0101	C	59	O	40	R	66
0102	C	100	C	78	C	142
0103	C	140	O	86	R	139
0104	C	134	C	127	C	171

C = Control
O = Zero nitrogen
R = Recovery

AVERAGE DAILY DERMAL NITROGEN LOSS

	Temp. Range 42-66°F.		Temp. Range 41-73°F.		Temp. Range 41-64°F.		Temp. Range 44-83°F		Temp. Range 45-74°F	
Subject	Diet	Nitrogen mg/day	Diet	Nitrogen mg/day	Diet	Nitrogen mg/day	Diet	Nitrogen mg/day	Diet	Nitrogen mg/day
0201	C	168	C	140	C	111	C	161	C	157
0202	C	130	C	146	C	108	C	146	C	106
0203	C	134	0	84	3	70	3	95	R	127
0204	C	151	3	92	R	124	0	91	R	143
0205	C	160	0	112	3	117	3	110	R	146
0206	C	124	0	70	R	120	3	94	R	133

C = Control
0 = Zero nitrogen
3 = 3+ g nitrogen
R = Recovery

AVERAGE DAILY DERMAL NITROGEN LOSS
(mg nitrogen/day)

Subject	Diet	Temp. Range 48-72°F
0302	C	204
0306	C	103
0307	C	127
0309	C	136
0310	C	103
0311	C	65
0301	G	71
0303	G	112
0304	G	119
0305	G	113
0308	G	122
0312	G	101

C = Control formula
G = Gemini foods

Table 45

MEAN DAILY DERMAL EXCRETION OF NITROGEN OF SUBJECTS

Study	Control Diet mg N/day	Protein-free Diet mg N/day	Low-Protein Diet mg N/day	Recovery Diet mg N/day
1	112	63	--	103
2	141	89	96	137
3	115	--	--	---
Weighted Average:	119±36	81±24	96±10	126±31

urea in sweat always exceeds that in blood. It had been shown previously by other investigators that when plasma urea level varied the concentration of urea in sweat remained proportional to that of plasma. The exact mechanism by which nitrogen is excreted in the sweat is not really known.

The percentage of urea nitrogen found in sweat also appears to vary, being reported as low as 25 to 30 percent and as high as 73 percent by various investigators (Reference 6). In our studies, blood urea nitrogen levels were correlated with the dermal excretion of nitrogen. This correspondence is shown in Figures 9 and 10. The correlation coefficient for each of the 4 experimental subjects who had varied protein intake was 0.95 or better. There was no significant correlation within the narrow range of blood urea nitrogen and sweat nitrogen for the 2 control subjects. When the results of the experimental subjects were pooled, the correlation coefficient was 0.82, indicating that there is a true relationship between the 2 variables. The correlation between blood urea nitrogen and the dermal excretion of nitrogen is highly significant as shown below.

SIGNIFICANCE OF CORRELATION BETWEEN BLOOD UREA NITROGEN AND THE DERMAL EXCRETION OF NITROGEN

Subject	0203	0204	0205	0206	total population
P value	0.009	0.011	0.005	0.003	less than 0.001

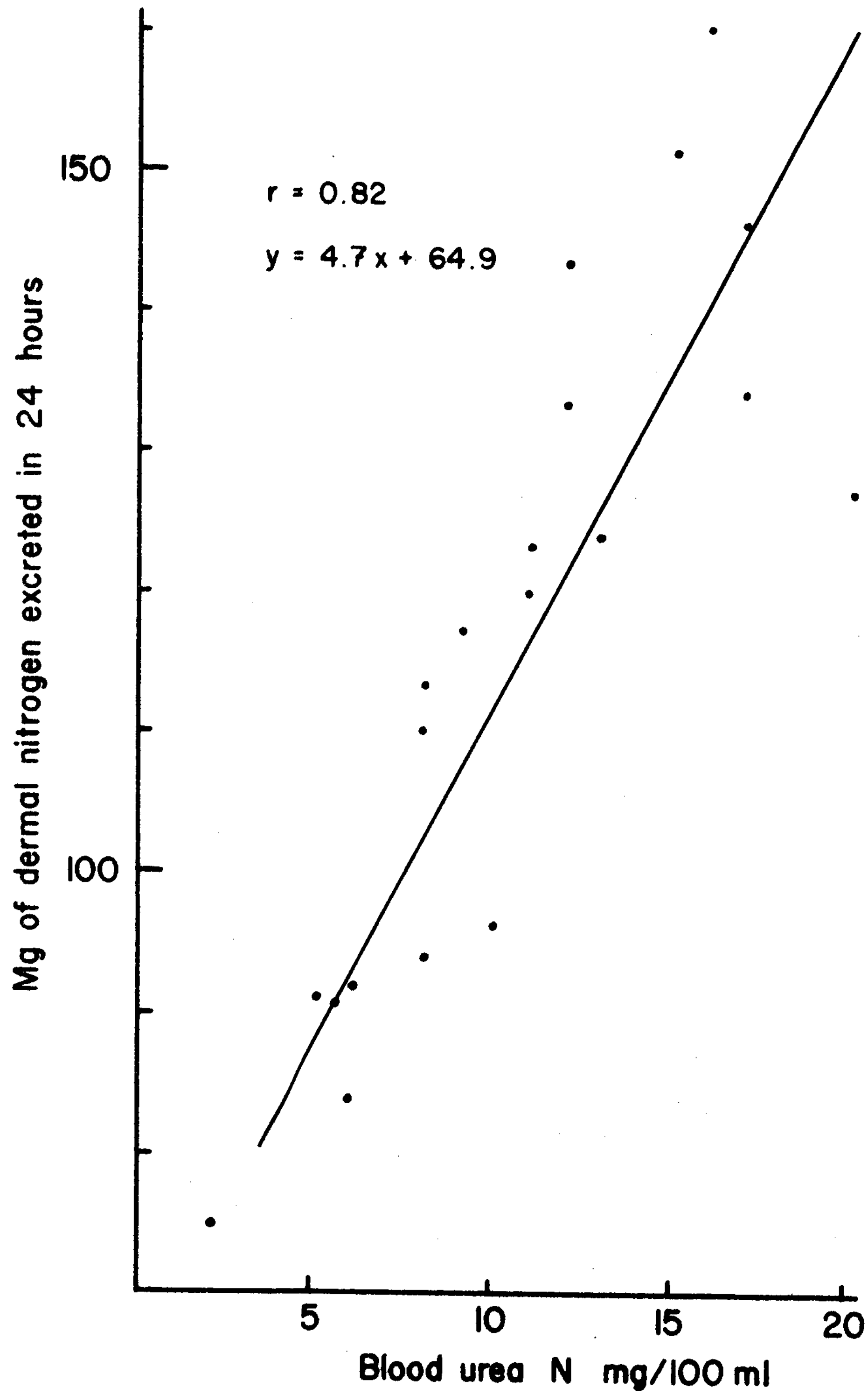


Fig. 9 Regression of dermal nitrogen excretion on blood urea nitrogen, 4 experimental subjects in study #2.

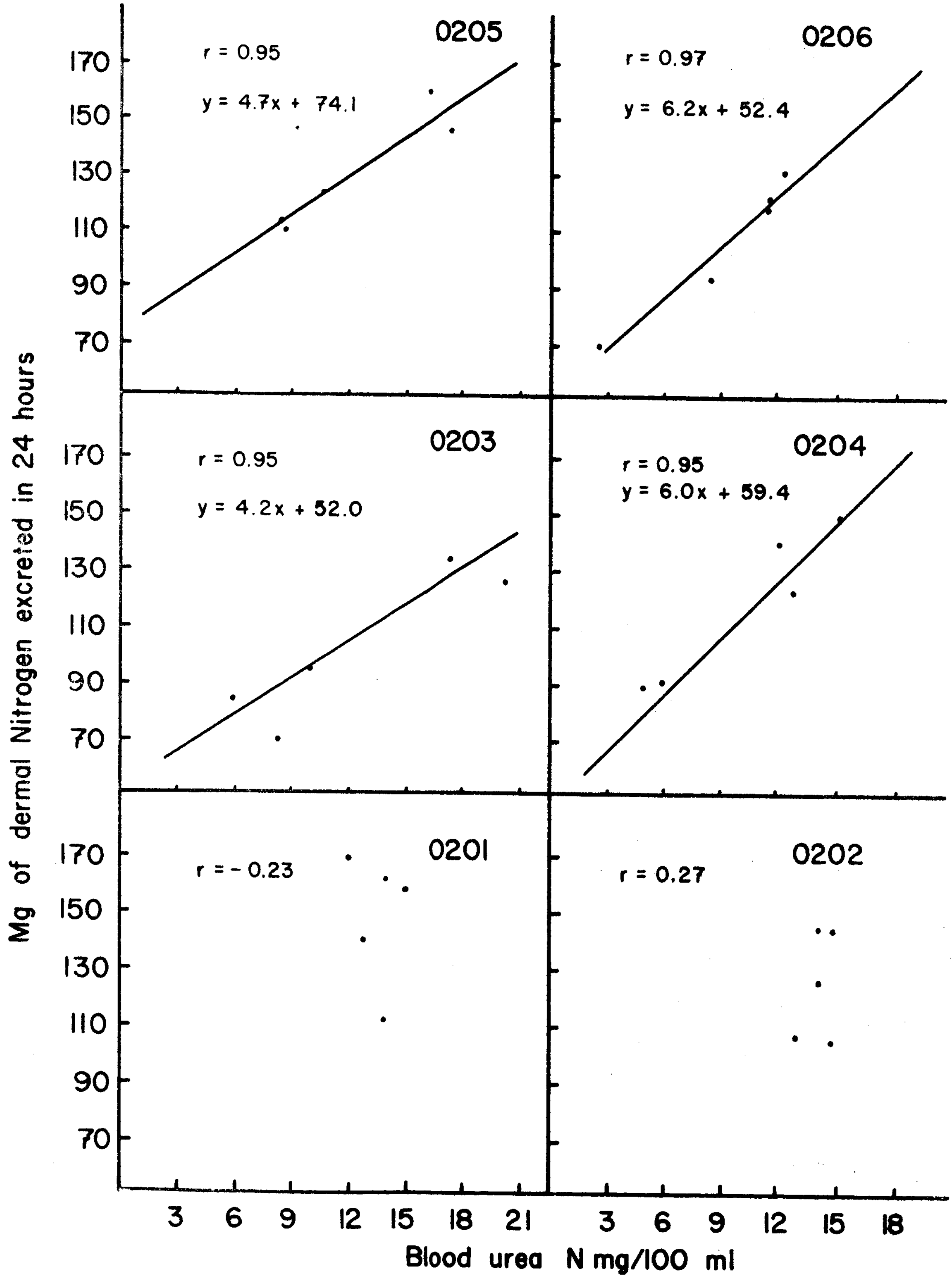


Fig. 10 Scatter diagram and regression of dermal nitrogen excretion on blood urea nitrogen in study #2.

E. Hair and Nail Losses

Beard weight was used to determine hair growth during the studies. The results of the first 2 studies are given in Figures 11 and 12. In Study #1 the beard weight remained relatively constant throughout the entire period. The slight reduction in weight at the end of the recovery period in subjects 0103 and 0102 cannot be explained by a latent effect of the diet on hair growth since both a control and an experimental subject were involved.

Beard growth seemed to be a little less constant in Study #2, although again protein intake does not appear to influence the rate of hair growth. The beard growth of subject 0203 fluctuated the most; he was the only subject who retained a mustache, which undoubtedly contributed to this variation in beard weight. Subjects 0204 and 0206 chose to shave more often than the one time at the end of each collection period. No record was kept of the number of times they shaved; however, their beard weights were quite constant throughout the study. After Study #2, the subjects were permitted to shave only at the end of each collection period. This was for two reasons: 1) epithelial tissue has been shown to be present in beard samples obtained with safety razors, and therefore each time the subject shaves a small amount of epithelial tissue is included with the hair; and 2) the question of whether shaving has an effect on the rate of hair growth is still unsettled.

Although animal studies have indicated significant effects of nutritional deficiencies on hair growth, little has been done in this area on man. It might well be anticipated that effects on hair growth will be more difficult to demonstrate in man, particularly since such a small percentage of the total protein intake is used for hair production in man compared with most animals. Furthermore, the effects of protein nutrition may not be easily seen in hair growth per se. In man, since each follicle appears to be independent of another, the effects may be noted on follicle formation and change before significant effects on hair growth can be observed. In subsequent experiments it is anticipated that hair will be plucked and effects upon formation of the hair follicle itself be observed, rather than the more indirect effects which would be more difficult to notice, namely rate of growth.

The mean daily beard weights during the third experiment are shown in Figure 13. The beard weights range from 1 to 119 mg/day. The average daily beard weights are also summarized in Table 46. This wide variation observed is to be expected since it is well known that beard growth rate is affected by many

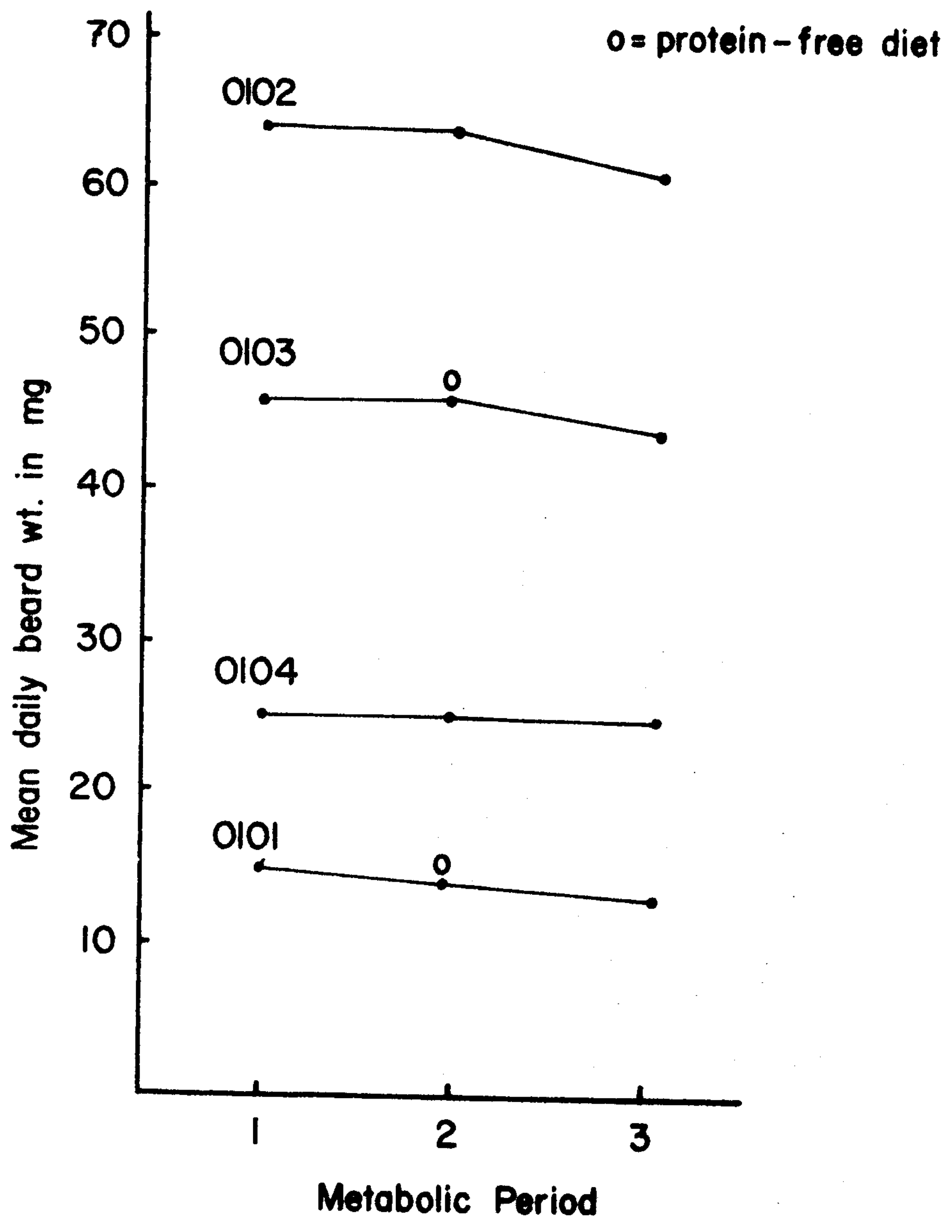


Fig. 11 Average daily beard weight by metabolic period for study #1.

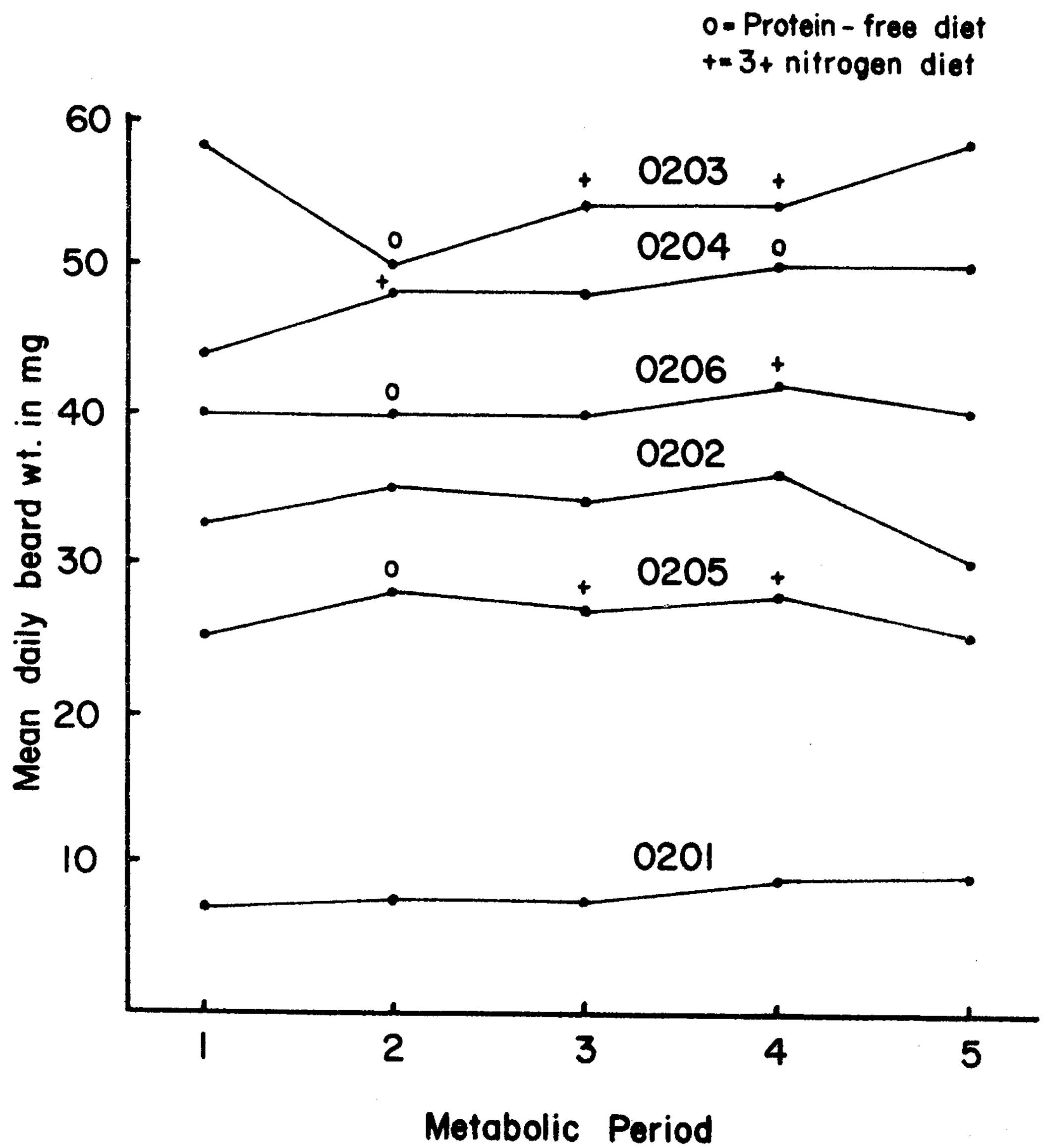


Fig. 12 Average daily beard weight by metabolic period for study #2.

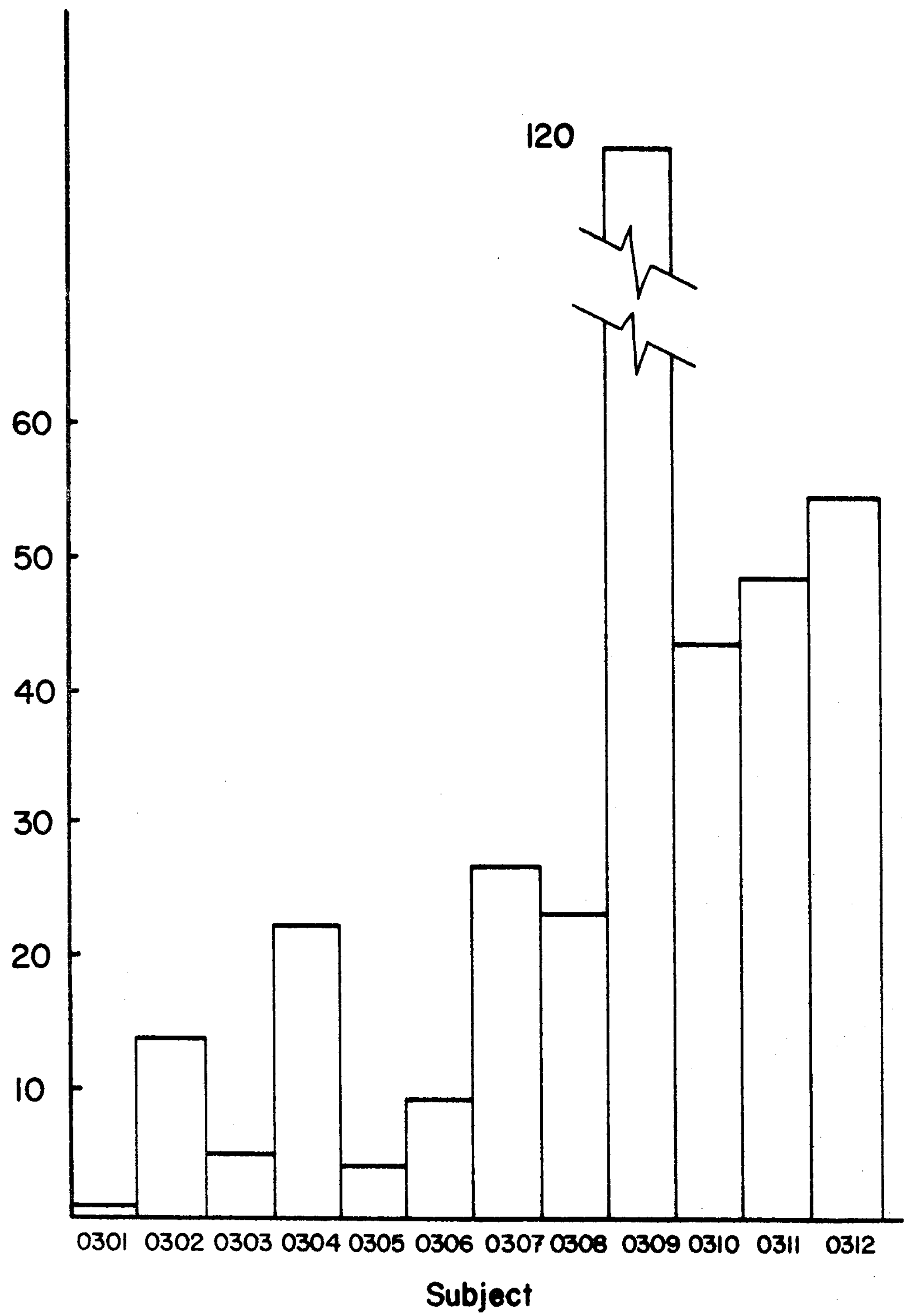


Fig. 13 Mean daily beard weight for each subject of study # 3.

Summary, Penthouse Studies 1, 2, and 3

Table 46

AVERAGE BEARD AND SCALP HAIR GROWTH

Subject	Beard Weight mg/day	Beard Weight g/year	Scalp Hair Weight mg/day	Scalp Hair Weight g/year	Total Scalp Hair and Beard Weight mg/day	Total Scalp Hair and Beard Weight g/year	Ratio Scalp Hair Weight/ Beard Weight
0101	14	5.1	222	81.0	236	86.1	15.8/1
0102	63	23.0	72	26.2	135	49.2	1.1/1
0103-0204	47	17.2	158	57.7	205	74.9	3.4/1
0104-0205	26	9.5	271	98.9	297	108.4	10.4/1
0201	8	3.0	209	76.3	217	79.3	26.1/1
0202	34	12.4	249	90.9	283	103.3	7.3/1
0203	55	20.1	71	25.7	126	45.8	1.3/1
0206	40	14.6	41	15.1	81	29.7	1.0/1
0301	1	0.3	131	47.8	132	48.1	131.0/1
0302	14	5.1	76	27.7	90	32.8	5.4/1
0303	5	1.8	64	23.4	69	25.2	12.8/1
0304	22	8.0	155	56.6	177	64.6	7.0/1
0305	4	1.5	150	54.8	154	56.3	37.5/1
0306	9	3.4	118	43.1	127	46.5	13.1/1
0307	27	9.9	157	57.3	184	67.2	5.8/1
0308	23	8.4	96	35.1	119	43.5	4.2/1
0309	119	43.4	71	26.1	190	69.5	0.6/1
0310	43	15.7	39	14.3	82	30.0	0.9/1
0311	47	17.2	147	53.7	194	70.9	3.1/1
0312	56	20.4	44	16.0	100	36.0	0.9/1
Average:	33±27	12.0	127±70	46.4	160±41	58.4	

factors, the principal ones in man being hormonal and genetic and the protein nutritional factor being apparently quite minor. The scalp hair collections were not used for studying the effects of protein on hair growth because these collections were not considered to be sufficiently accurate.

In the first 2 experiments the scalp hair weights from each of the metabolic periods were pooled and divided by the total number of days to give an average daily scalp hair weight for the entire study, which would closely approximate the actual daily hair weights. The mean daily head hair weight for the population was 127 mg, approximately 4 times the beard weight. The coefficient of variation for the scalp hair weight is 0.55 as compared with 0.81 for the beard weight, indicating that there is a smaller amount of scattering about the mean for the scalp hair. When the scalp hair and beard weight were added together, the mean daily weight was 160 mg, with a coefficient of variation of 0.41, indicating less deviation among the sums of the weights than for the individual weights. There was no correlation between scalp hair weight and beard weight. The average yearly facial hair and scalp loss is 12.0 and 46.4 g., respectively, giving a total of 58.4 g.

Table 47 summarizes the mean daily nail growth for each subject; Table 48 lists the average daily nail growth for subjects in Study #2. The population mean was 0.093 mm/24 hours. The range was from 0.069 to 0.125 mm. These values are close to those previously reported in the literature (Reference 2). In Figure 14 the average growth rate by metabolic period for Study #2 for each subject is shown. Although there appears to be some retardation during the administration of the low or zero protein diet, there is no constant influence of the diet on nail growth rate. If low protein diets do have an effect on nail growth rate, the effect certainly cannot be seen in periods of 18 to 36 days duration.

The facial and scalp hair and the nails were analyzed for nitrogen. The percentage of nitrogen found in these appendages is shown in Tables 49, 50, and 51. The nitrogen content of the hair of the subjects ranged from 12.80 to 15.37 percent, with a mean value of 14.39. Not only was there no effect of alteration in nitrogen content of the diet on hair growth, but neither was there any change in percentage of nitrogen in the hair. Although there was some fluctuation in nitrogen content, the lower levels of nitrogen content did not correlate with periods of decreased protein intake. The fluctuation of nitrogen content in the hair of an individual is probably due to techniques of collection: First, the hair was not defatted prior to analysis; and, second, the facial and scalp hair and the nails were analyzed together in the first two studies.

AVERAGE DAILY NAIL GROWTH

Subject	Nail Growth mm/day
0101	0.091
0102	0.105
0103-0204	0.099
0104-0205	0.105
0201	0.099
0202	0.086
0203	0.088
0206	0.108
0301	0.093
0302	0.093
0303	0.100
0304	0.086
0305	0.108
0306	0.106
0307	0.069
0308	0.110
0309	0.079
0310	0.083
0311	0.070
0312	0.079
Average:	0.093±0.011

AVERAGE DAILY NAIL GROWTH

Subject	Growth, mm/day
0201	0.099 ± 0.004
0202	0.086 ± 0.004
0203	0.088 ± 0.002
0204	0.096 ± 0.011
0205	0.101 ± 0.005
0206	0.108 ± 0.008

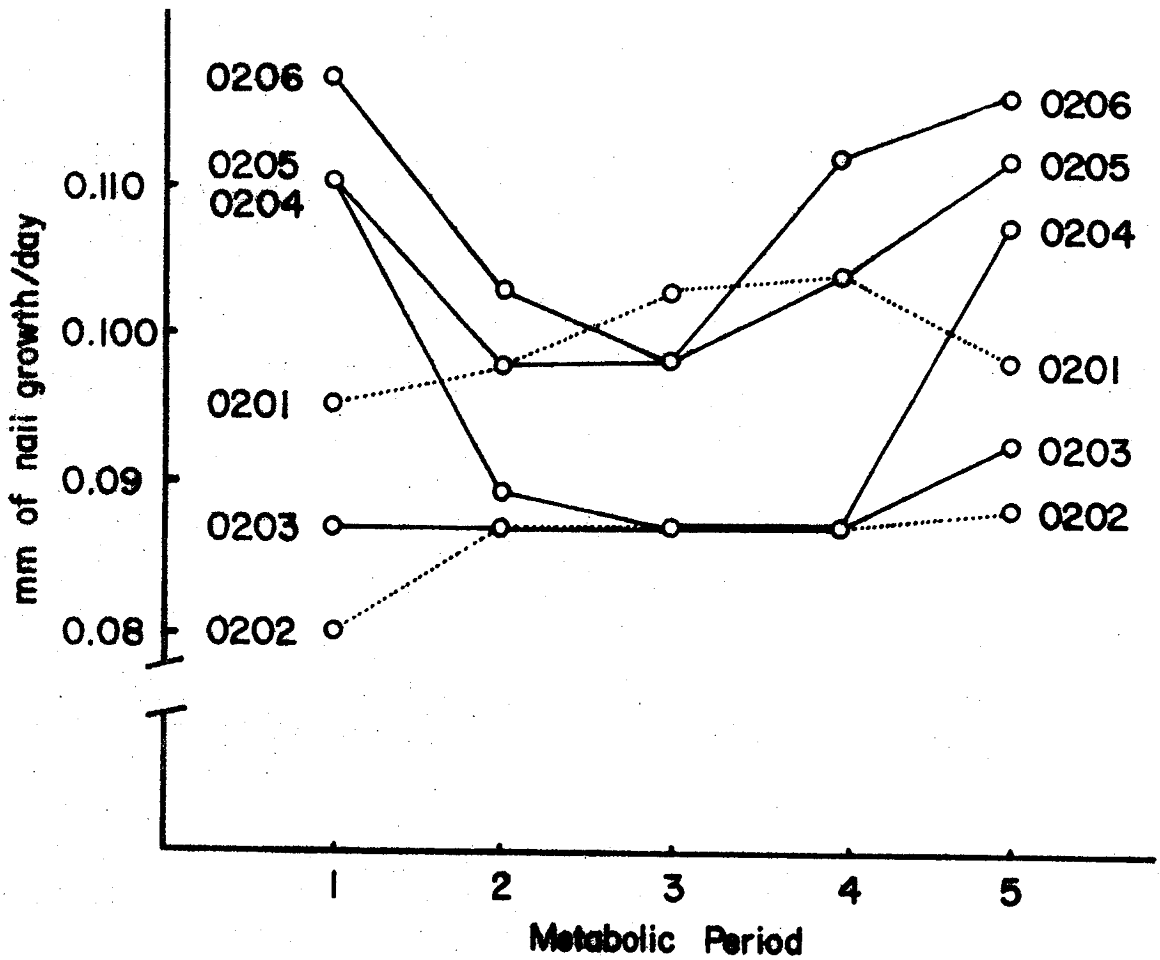


Fig. 14 Mean daily nail growth in mm, Study 2

PERCENT OF NITROGEN IN HAIR AND NAILS

Subject	Period 1	2	3	4	5	Mean and Standard Deviation
0102	13.80	13.98	14.49	---	---	14.09±0.36
0103	14.61	14.10*	14.46	---	---	14.39±0.26
0104	14.40	14.19	14.85	---	---	14.48±0.34
0201	14.11	14.77	14.53	14.38	14.38	14.43±0.24
0202	13.63	12.93	14.13	14.45	14.21	13.87±0.61
0203	12.80	14.32*	15.21+	14.46+	14.73	14.30±0.90
0204	13.91	14.02+	14.38	14.07*	14.25	14.13±0.19
0205	14.08	14.24*	14.65+	14.54+	14.74	14.45±0.28
0206	13.53	13.75*	14.04	14.28+	13.86	13.89±0.39

*Protein free

+3+ g nitrogen

PERCENT NITROGEN IN HAIR AND NAILS

Subject	Percent Nitrogen in Beard	Percent Nitrogen in Nails and Scalp Hair	Difference	Percent Nitrogen of Combined Samples
0301	13.86	14.30	0.44	14.29
0302	11.07	14.57	3.50	14.43
0303	12.30	14.33	2.03	14.30
0304	13.44	14.42	0.98	14.39
0305	11.95	14.62	2.67	14.60
0306	12.56	14.57	2.01	14.53
0307	13.86	15.45	1.59	15.37
0308	12.46	14.79	2.33	14.65
0309	13.85	14.87	1.02	14.26
0310	14.03	14.63	0.60	14.52
0311	14.09	14.74	0.65	14.69
0312	14.04	14.02	0.02	14.03
Average:	13.13±1.02	14.61±0.37	1.48	14.51±0.33

Mean for Population: 14.39±0.33 percent

Range: 12.80-15.37 percent

WEIGHT AND NITROGEN CONTENT OF HAIR AND NAILS

Subject	Hair weight, mg./24 hours Facial	Scalp	Nitrogen lost as hair and nails, mg./24 hours
Gemini			
0301	<1	131	21
0303	5	64	11
0304	22	155	28
0305	4	150	24
0308	23	96	19
0312	56	44	15
Formula			
0302	14	76	15
0306	9	118	20
0307	27	157	29
0309	119	71	28
0310	43	39	14
0311	47	147	30

In the third experiment, the facial hair was analyzed separately, and the nitrogen content of this hair was lower than that of scalp hair, ranging from 11.07 to 14.09 percent. These lower values may be due to skin contamination which was always noted when shaving with a safety razor. In Study #3 the percentage of nitrogen in the nails ranged from 14.50 to 14.80; the mean percentage of nitrogen in the scalp hair and the nails together during this Study was 14.61.

Table 52 shows the average daily and yearly loss of nitrogen from the scalp and facial hair and the nails. The mean daily loss of nitrogen under these circumstances was 24 mg/day, or 8.8 g/year. The average daily nitrogen loss from the integument by metabolic period is shown in Tables 53 and 54. The decreased nitrogen shown during periods of protein depletion, as can be noted from the data above, is due to decrease in nitrogen loss through the skin and so is not due to any alteration in nitrogen content or growth rate of nails or hair. The nitrogen loss from the integument of the subjects on the control diet was 143 ± 32 mg/day, or 74 ± 18 mg/day per square meter of body surface area.

AVERAGE DAILY AND YEARLY LOSS OF NITROGEN FROM SCALP, FACIAL HAIR, AND NAILS

Subject	Nitrogen* mg/day	Nitrogen* mg/year
0101	35	12.8
0102	20	7.3
0103-0204	31	11.3
0104-0205	44	16.1
0201	33	12.0
0202	41	15.0
0203	19	6.9
0206	12	4.4
0301	20	7.3
0302	15	5.5
0303	11	4.0
0304	28	10.2
0305	24	8.8
0306	20	7.3
0307	29	10.8
0308	19	6.9
0309	28	10.2
0310	14	5.1
0311	29	10.6
0312	15	5.5
Average:	24 ± 9.4	8.8

*A factor of 0.1439 was used to determine the amount of nitrogen

AVERAGE DAILY NITROGEN LOSSES FROM THE INTEGUMENT
(Head hair, nails, and skin, plus sweat and beard)

Subject	mg Nitrogen/Metabolic Period 1	2	3	4	5
0101	94	75*	101	----	----
0102	120	98	161	----	----
0103	171	117*	170	----	----
0104	178	171	215	----	----
0201	201	173	144	194	190
0202	166	187	149	187	147
0203	153	103*	89+	114+	146
0204	182	123+	155	122*	174
0205	204	156*	161+	154+	190
0206	136	82*	132	106+	146

*Protein-free
+3+ g nitrogen

Formula Subjects	mg Nitrogen
0302	219
0306	123
0307	156
0309	164
0310	117
0311	94

Gemini Subjects	mg Nitrogen
0301	91
0303	123
0304	147
0305	137
0308	141
0312	116

AVERAGE DAILY NITROGEN LOSSES FROM THE INTEGUMENT PER SQUARE METER OF BODY SURFACE AREA

(Head and facial hair, nails, and skin, plus sweat)

Subject	mg Nitrogen/Metabolic Period 1	2	3	4	5
0101	48	38*	52	----	----
0102	69	56	93	----	----
0103	96	63*	92	----	----
0104	87	84	106	----	----
0201	103	88	73	99	97
0202	90	99	79	99	78
0203	79	53*	47+	60+	76
0204	98	66+	84	66*	94
0205	100	77*	79+	75+	93
0206	79	51*	77	62+	85

* Protein-free

\+ 3+ g nitrogen

Formula Subjects	mg Nitrogen
0302	115
0306	56
0307	80
0309	80
0310	63
0311	44
Gemini Subjects	
0301	55
0303	58
0304	73
0305	70
0308	76
0312	61

F. Integumentary Losses in Sweat

As mentioned previously, in Study #3 sweat was collected from the subjects during the interval of testing under increasing work loads on a bicycle ergometer. The weight change (chiefly water loss) was substantial during the short bout of bicycle work, averaging about 350 g. This demonstrates that the activity was sufficient to induce active sweating.

The amount of sweat collected at the several body sites was quite variable; and it did not correlate with the degree of total weight loss, although the arm bag volume appeared to be superior to pad collections in this respect. The lactic acid content of the sweat collected in the arm bag was on the average more than twice as high as that collected on the pads. The osmolarity of the arm bag sweat of the Gemini subjects was higher than that of the formula subjects (Table 55) as were sodium and chloride content of all sweat samples (Table 56). These higher values are probably related to the higher dietary sodium chloride intake of the Gemini group.

Although the levels of sodium in the various sweat samples were not the same, they were significantly correlated in most cases. The correlation coefficient (R) of arm bag to total body sweat sodium was +.83, and the relationship is described by the equation:

$$TB_{N_9} = 0.338\ A_{N_9} + 0.213$$

where TB = total body and A = arm bag sweat concentrations of sodium.

Potassium, calcium, and magnesium were present in much lower concentration than were sodium and chloride and did not differ between groups, as shown by the following:

AVERAGE TOTAL BODY SWEAT LOSSES
DURING ACUTE SWEATING (in mg)

	Gemini Diet	Formula Diet
Sodium	214	151
Potassium	70	72
Calcium	25.2	26.2
Magnesium	5.2	5.1
Chloride	294	187
Urea	87.5	79.2

Table 55

VOLUME, LACTIC ACID CONTENT, AND OSMOLARITY OF SWEAT COLLECTED DURING BICYCLE ERGOMETER TEST*

Subject	Body** Weight Loss g.	Weight of sweat collected, g — Pad collection mid-ax	back	chest	arm-bag	Lactic Acid Content of Sweat, mg/g — Pad collection mid-ax	back	chest	arm-bag	Osmolarity arm-bag sweat mosm/l
Gemini Group										
0301	230	0.245	0.622	1.020	0.3	1.20	1.37	1.37	1.25	52
0303	420	0.717	1.892	3.126	5.2	1.31	1.18	1.27	2.62	221
0304	350	0.386	0.988	1.280	1.5	1.12	1.36	1.31	3.35	284
0305	360	0.639	1.542	0.926	1.2	1.55	1.38	1.44	2.79	164
0308	350	0.502	1.512	0.996	2.0	1.18	1.15	1.03	4.08	266
0312	420	0.624	1.932	1.924	5.8	1.44	1.73	1.23	2.75	188
Mean	350	0.519	1.415	1.545	2.7	1.29	1.36	1.27	2.80	196
S.D.	70	.161	.470	.783	2.0	.20	.18	.15	.86	76
Formula Group										
0302	380	0.680	0.934	0.279	0.5	1.51	1.48	1.27	1.91	73
0306	270	0.210	0.631	0.282	1.3	1.43	1.34	1.11	2.98	147
0307	470	0.510	1.124	1.079	5.1	1.55	1.58	2.00	2.40	188
0309	390	0.591	1.097	0.622	1.5	1.51	1.52	1.37	7.30	166
0310	290	0.653	1.179	0.850	2.7	1.48	1.51	1.26	3.54	193
0311	400	0.973	1.902	1.767	3.4	1.13	1.09	1.20	2.40	132
Mean	360	0.603	1.144	0.813	2.4	1.43	1.41	1.36	3.18	150
S.D.	70	.226	.386	.514	1.6	.16	.22	.32	2.19	40

* During 48 ergometry tests, barometric pressure was 75.5 ± 0.15 mm Hg and temperature 24.4 ± 0.05°C. Measurements were made on the following days of study: 3-5; 16-18; 29-31; and 42-44.

** Each value is the mean of 4 separate trials for each subject; for group mean and deviation, N = 6. Body weight loss is assumed to represent total body sweat loss, i.e., respiratory water loss is disregarded.

Table 56

MINERAL CONTENT OF SWEAT COLLECTED BY VARIOUS METHODS DURING BICYCLE ERGOMETER TEST

S	Sodium mg/g sweat* Pad Collection					Potassium mg/g sweat* Pad Collection					Total Body "Sweat"*		
	Mid-ax.	Back	Chest	Arm Bag	Total Body	Mid-ax.	Back	Chest	Arm Bag	Total Body	Calcium mcg/g	Magnesium mcg/g	Chloride mg/g
Gemini													
0301	0.32	0.72	0.65	0.21	0.39	0.31	0.27	0.30	0.24	0.24	85	19	0.34
0303	1.66	1.84	2.06	1.65	0.89	0.29	0.23	0.24	0.48	0.19	73	15	1.27
0304	1.59	2.28	2.44	1.73	0.87	0.19	0.16	0.16	0.44	0.17	69	18	1.24
0305	0.67	0.93	0.99	1.00	0.50	0.27	0.26	0.27	0.57	0.24	74	12	0.66
0308	1.23	2.33	1.51	1.57	0.62	0.30	0.19	0.20	0.14	0.20	76	14	0.82
0312	0.99	1.55	2.19	1.09	0.59	0.24	0.30	0.21	0.56	0.17	54	12	0.72
Mean	1.07	1.60	1.63	1.20	0.64	0.27	0.24	0.23	0.41	0.20	72	15	0.84
Std.Dev	0.48	0.63	0.66	0.54	0.19	0.04	0.05	0.04	0.05	0.04	10	3	0.34
Formula													
0302	0.52	0.38	0.52	0.24	0.20	0.28	0.20	0.20	0.40	0.18	55	11	0.23
0306	0.85	1.07	1.08	0.74	0.32	0.22	0.20	0.14	0.57	0.23	90	22	0.44
0307	0.79	1.12	1.26	0.75	0.40	0.30	0.37	0.35	0.69	0.22	56	24	0.74
0309	1.63	1.49	1.66	0.54	0.56	0.22	0.20	0.25	0.46	0.22	100	17	0.60
0310	0.96	1.17	1.46	1.12	0.56	0.20	0.20	0.19	0.66	0.22	81	15	0.64
0311	1.32	1.37	1.42	0.69	0.48	0.21	0.17	0.15	0.39	0.15	62	12	0.63
Mean	1.01	1.10	1.23	0.68	0.42	0.24	0.23	0.21	0.53	0.20	74	17	0.52
StdDev.	0.36	0.34	0.37	0.26	0.13	0.04	0.07	0.07	0.04	0.01	17	5	0.17
Correlation Coefficients													
Mid-ax.		0.51	0.57	0.56	0.55		0.32	0.41	0.04	0.26			
Back			0.66	0.67	0.67			0.40	0.15	0.30			
Chest				0.68	0.75				0.14	0.34			
Arm					0.83**					0.06			

**Body "sweat" Na conc. = 0.338 arm-bag sweat Na concentration + 0.213.

*Each value is the mean of 4 separate collections from each subject; ∴, for group mean and deviation, N=6. Individual values were used to compute correlation coefficients and regression equations; ∴ N = 48.

It can be noted that the losses of both sodium and potassium are of moderate degree compared to the intake. However, it is rather important to note that although the calcium concentration is low the amount lost through the skin in a short period of time is a very high proportion of the daily urinary loss. In fact, were this degree projected to a 24-hour loss on the basis of this degree, the amount of loss would be considerable and greater than the urinary loss.

During the bicycle work nitrogen concentration of total body sweat was .32 and .34 mg/g for the formula and Gemini groups, respectively. Total losses during this brief period were 115 and 119 mg, respectively (Table 57). These losses observed over a short time are similar to the total daily body losses observed in our experimental subjects during normal activity on normal protein intakes. The total body losses observed in Study #3 were slightly greater during the second collection interval than the first when ambient temperatures were about 5° F. higher.

Table 57

UREA AND NITROGEN CONTENT OF SWEAT COLLECTED BY VARIOUS METHODS DURING BICYCLE ERGOMETER TEST

and

DAILY TOTAL BODY "SWEAT" NITROGEN LOSS OF AMBULATORY SUBJECTS

S	Urea mg./g. sweat* Pad collection Mid-ax	Back	Chest	Arm Bag	Total Body	Nitrogen mg./g. sweat* Pad collection Mid-ax	Back	Chest	Arm Bag	Total Body	Total Body Nitrogen** mg./day I	II
Gemini Group												
0301	0.47	0.53	0.47	0.35	0.23	0.44	0.39	0.35	0.45	0.36	61	80
0303	0.42	0.34	0.27	0.39	0.17	0.34	0.26	0.21	0.93	0.32	107	116
0304	0.55	0.52	0.49	1.10	0.27	0.42	0.40	0.35	1.50	0.36	100	137
0305	0.67	0.57	0.58	0.90	0.33	0.52	0.43	0.38	0.95	0.38	107	119
0308	0.62	0.52	0.56	1.47	0.30	0.38	0.37	0.35	1.78	0.39	105	139
0312	0.62	0.66	0.54	0.80	0.23	0.42	0.34	0.46	0.86	0.25	85	116
Mean	0.56	0.52	0.48	0.83	0.25	0.42	0.37	0.35	1.08	0.34	94	118
Std.Dev	0.07	0.11	0.12	0.40	0.07	0.06	0.06	0.06	0.44	0.06	16.7	19.4
Formula Group												
0302	0.68	0.60	0.56	0.49	0.26	0.55	0.42	0.54	0.67	0.35	203	204
0306	0.39	0.36	0.26	0.76	0.23	0.46	0.35	0.40	1.09	0.38	96	109
0307	0.40	0.45	0.56	0.40	0.18	0.39	0.68	0.50	0.94	0.25	95	158
0309	0.55	0.46	0.52	1.05	0.27	0.33	0.34	0.38	1.01	0.31	99	172
0310	0.48	0.53	0.43	0.89	0.24	0.42	0.40	0.36	1.22	0.41	105	100
0311	0.45	0.42	0.40	0.45	0.17	0.27	0.25	0.24	0.58	0.20	57	73
Mean	0.49	0.47	0.45	0.67	0.22	0.40	0.41	0.40	0.92	0.32	109	136
Std.Dev	0.10	0.07	0.12	0.25	0.06	0.09	0.13	0.10	0.18	0.05	45	45

Correlation Coefficients

	Urea Back	Chest	Arm Bag	Total Body	Nitrogen Back	Chest	Arm Bag	Total Body
Mid-ax	0.73	0.67	0.29	0.38	0.17	0.69	0.07	0.06
Back		0.53	0.09	0.24		0.28	0.04	0.20
Chest			0.15	0.13			0.07	0.10
Arm				0.57***				0.40***

*Each value is the mean of 4 separate collections from each subject, . for group mean and deviation N=6. Individual values were used to compute correlation coefficients and regression equations, ∴ N=48.

**Value obtained over six days of continuous collection. See text for method. Berkeley temperatures period I 48 to 67°F; period II 50 to 72°F.

***Regression equations, where Y= concentration in total body "sweat" and X= concentration in arm-bag sweat: Urea Y=0.103x + 0.153, Nitrogen Y= 0.131x + 0.188

G. Saliva and Semen Losses

During Study #1 both saliva and semen were collected to study the effect of nitrogen intake on nitrogen loss in these secretions as well as any possible effect of dietary protein on spermatogenesis.

As mentioned previously, except for these collections of saliva for nitrogen content, all salivary secretions were swallowed. The results of nitrogen content of saliva were so variable that they are not reported.

The results of the semen collection are shown in Table 58. Considerable variation is noted in the sperm count as well as in total nitrogen excretion. The amount of nitrogen lost by this route is quite small. The volume of ejaculate was variable. There appeared to be no correlation between either total nitrogen or nitrogen/ml and dietary protein variation. In view of this lack of any significant trend and the great variation, collections of these materials in subsequent experiments were not attempted.

SPERMATAZOA AND NITROGEN IN SEMEN

SUBJECT	Spermatazoa x 10^6/ml. Test Period B III	Spermatazoa x 10^6/ml. Recovery Period IV	Nitrogen, mg/ml. Test Period B III	Nitrogen, mg/ml. Recovery Period IV
0102	65	165	-	12.20
	64	46	7.86	8.06
	114	118	12.16	11.80
0104	70	74	-	9.10
	64	122	12.36	11.90
	123	45	12.23	10.32
0103	110	47	-	14.81
	130	63	14.36	13.42
	84	83	13.52	12.11
0101	102	49	-	9.67
	12	93	10.84	11.70
	93	48	11.45	12.21

H. Gases of Intestinal Origin

The techniques for measurement of gases of intestinal origin were not instituted in our laboratory until Study #3. In this Study, it was possible to evaluate the intestinal gas production of the formula diet (tested only at the normal protein level) and contrast this with the gas production on the Gemini diet.

Beyond question, the Gemini diet is more evocative of intestinal gas than is the formula diet. Hydrogen concentration of expired air showed typical sharp peaks 4 to 6 hours after consumption of some of the Gemini meals, more noticeably in subjects 0301, 0303, and 0308 than in the others (Table 59b). Among the formula subjects elevations of breath hydrogen were rare and were marginal when they did occur (e.g., maximum 13 PPM for subjects 0307 and 0309 as contrasted with levels of 154 PPM for subject 0301 and 68 PPM for subject 0308). Methane concentration varied little throughout the day or in response to diet but was characteristically high or low for a given subject (Table 59a-c).This latter observation is in accord with previous experience in our laboratory.

Total flatus gas varied widely among subjects within a dietary group (Tables 60 and 61. Gemini subjects 0301 and 0308 fit a pattern we have noted in other experiments: the subjects evolve large amounts of hydrogen, particularly in anxiety-producing situations. Both subjects produced large volumes of gases on the first and unquestionably stressful experience of flatus collection. On the second trial the gas production was markedly decreased.

The reasons for these marked, observed differences in gas production that appear to be related to anxiety are unclear. Until further studies are performed on rates of diffusion of gases through the intestinal epithelium, it is impossible to determine whether some of these changes are associated with changes in diffusion and blood flow or what influence alterations in pulmonary ventilation and alveolar diffusion may have on these processes.

No "hydrogen producers" were noted in the formula diet, although subjects 0307 and 0309 appeared to behave like such. It is likely that the formula provides little substrate for bacterial action in the ileum or proximal portion of the large bowel. The only large volume of flatus recorded among the formula group consisted chiefly of nitrogen, which places the probable origin as air swallow or transfer into the gut from the blood.

BREATH HYDROGEN AND METHANE CONCENTRATION

Hour: Formula Subject	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	AVE.
							HYDROGEN, PPM							
0302 a*	1	2	4	5	4	3	3	2	15	12	4	-	-	5
b	1	1	1	1	1	2	3	1	2	2	1	2	4	2
0306 a	3	2	3	3	3	3	3	6	3	2	6	-	-	3
	1	1	1	4	1	1	1	1	3	1	4	1	1	2
b	-	2	9	6	2	6	6	2	2	1	1	1	1	3
0307 a	1	9	2	2	1	-	1	3	4	5	-	-	-	[illegible]
b	1	1	2	4	2	4	6	13	13	11	7	4	-	6
0309 a	6	10	11	8	3	2	1	12	2	-	-	-	-	6
	1	13	7	2	1	7	20	7	0	3	1	2	16	6
b	1	1	1	2	4	7	4	5	4	2	1	1	-	3
0310 a	1	1	3	2	1	1	2	3	4	3	2	-	-	[illegible]
	-	1	1	1	1	3	2	3	4	2	2	4	6	3
b	-	2	1	3	4	4	2	1	3	2	1	1	1	2
0311 a	1	1	2	1	2	1	1	1	2	-	-	-	-	1
	8	10	6	1	2	1	1	-	-	-	-	-	-	4
b	3	3	3	20	10	2	6	2	2	1	1	1	1	4
							METHANE, PPM							
0302 b	5	5	3	2	3	4	2	4	4	4	10	7	5	4
0306	-	3	4	3	3	3	3	3	4	3	6	4	4	4
b	-	4	9	4	3	2	2	3	4	3	4	4	4	4
0307 b	3	2	2	2	2	2	2	2	2	3	3	3	-	2
0309	20	47	26	11	6	14	21	26	11	27	18	31	54	24
b	17	12	12	13	16	15	15	15	12	25	16	13	-	[illegible]
0310	3	2	3	2	2	2	3	3	3	3	3	4	4	3
b	-	4	3	3	3	2	2	3	2	3	10	3	3	3
0311	31	20	20	17	21	11	10	-	-	-	-	-	-	18
b	15	21	14	20	16	17	16	12	16	16	18	15	13	16

continued

Penthouse Study #3
Breath Hydrogen and Methane Concentration

Table 59b

Gemini Subject	Menu	HYDROGEN, PPM													AV.
		1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	
0301	GI	4	1	1	2	51	115	116	154	55	31	12	21	17	47
	GII	1	1	8	18	21	50	24	9	6	7	3	2	10	12
	GII*	-	1	2	19	19	12	13	6	6	12	6	4	6	9
	GIII*	12	9	13	50	25	33	41	17	23	36	25	-	-	26
	GIII	1	5	6	6	19	45	48	23	31	8	8	5	12	17
0303	GI	1	1	1	1	2	4	13	9	9	10	8	6	10	6
	GI*	1	1	2	4	3	5	10	7	5	4	5	1	-	4
	GII*	3	2	25	16	6	7	7	4	3	-	-	-	-	8
	GII	-	3	4	4	11	17	11	5	6	3	5	3	5	6
	GIII	1	10	22	19	18	19	28	17	31	1	8	-	8	15
0304	GI	6	1	1	9	1	6	11	2	5	1	5	7	0	4
	GI*	2	3	9	13	8	1	3	8	7	8	12	5	-	7
	GII*	4	4	8	3	3	3	2	4	5	-	-	-	-	4
	GII	-	1	1	1	3	7	4	2	2	2	1	5	3	3
	GIII	1	1	3	3	3	3	2	6	13	10	9	9	8	6
0305	GI*	-	3	4	9	3	4	5	11	11	21	4	1	-	7
	GII	1	2	4	4	1	1	1	1	3	1	1	1	1	2
	GIII	1	1	3	1	5	4	1	-	-	-	-	-	-	2
	GIII*	1	0	1	2	1	1	2	2	6	1	1	1	3	2
0308	GI	2	5	9	3	2	11	4	8	8	10	10	5	6	6
	GII	8	4	3	5	6	10	17	19	8	5	6	3	3	8
	GII*	-	10	1	2	1	19	3	8	3	9	4	5	10	6
	GIII*	4	1	5	-	8	6	29	12	22	68	22	-	-	18
	GIII	1	0	1	2	1	7	1	26	29	9	11	7	11	8
0312	GI*	3	9	3	2	3	7	14	4	20	2	2	-	-	6
	GII	1	2	44	8	3	1	0	11	12	5	2	2	3	7
	GIII	2	2	5	11	4	6	9	3	9	4	1	8	5	5
	GIII*	6	3	3	1	1	2	5	7	10	3	1	3	2	4

continued

Penthouse Study #3
Breath Hydrogen and Methane Concentration

Table 59c

METHANE, PPM

Gemini Subject	Menu	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	AV.
0301	I	3	3	3	2	2	2	2	2	3	3	3	3	4	3
	II	3	3	4	3	3	2	3	3	3	3	3	3	4	3
	II*	-	4	3	3	3	2	2	2	2	2	3	4	4	3
	III	4	3	3	2	4	3	3	5	4	4	4	4	4	4
0303	I	3	3	3	2	3	3	3	3	3	3	4	3	4	3
	I*	11	8	11	11	11	15	17	15	16	22	12	17	-	13
	II	4	4	4	3	4	3	3	4	5	5	5	6	8	4
	III	8	9	8	4	3	3	4	4	5	4	5	-	6	5
0304	I	3	3	2	9	3	6	6	3	3	7	3	3	8	4
	I*	-	2	2	2	2	2	3	3	4	2	4	3	4	3
	II	2	2	2	2	3	2	3	3	3	3	5	4	4	3
	III	4	4	5	4	3	3	3	3	4	3	5	4	4	4
0305	II	36	33	22	36	23	12	17	27	35	25	34	25	22	25
	III	30	25	26	26	43	23	13	-	-	-	-	-	-	27
	III*	17	15	15	23	14	21	20	20	29	17	23	40	36	22
0308	I	3	3	9	3	6	3	3	3	3	3	3	3	4	4
	II	4	6	4	5	3	3	3	12	4	3	4	4	4	5
	II*	-	-	5	4	3	11	3	8	3	10	6	4	5	6
	III	10	4	4	4	3	3	3	3	4	5	4	4	4	4
0312	II	3	4	-	5	7	3	3	12	5	4	3	3	4	6
	III	7	6	5	10	3	3	3	4	4	5	4	10	5	5
	III*	3	3	3	3	3	3	3	8	14	8	4	7	4	5

*Simultaneous flatus collection; a = day 3-5, b = day 40-42.

FLATUS GASES AND RESPIRATORY HYDROGEN EXCHANGE
(from 1000 through 2200 hours)

Gemini Menu	Subject	Days 3-5 Dry flatus gases, ml. Total	CO_2	O_2	N_2	CH_4	H_2	Respiratory H_2 Exchange, ml.*	Total H_2 ml.
III	0301	492	75	17	158	0	209	156	365
II	0303	274	70	9	141	1	32	48	80
II	0304	554	50	19	466	0	3	24	27
I	0305	101	14	11	54	60	10	42	52
III	0308	146	16	8	66	0	42	108	150
I	0312	149	16	8	70	0	17	36	53
	Ave.	286	40	12	159	10	52	69	121
Formula	0302	Tube plugged						30	>30
	0306	33	4	3	26	0	0	18	18
	0307	69	2	12	54	0	0	18	18
	0309	130	10	7	100	3	3	36	39
	0310	26	<1	5	18	0	0	12	12
	0311	264	24	14	165	54	0	6	6
	Ave.	104	82	8	73	6	1	20	>20

*Assumed pulmonary ventilation 500 liters per hour or 6×10^6 ml. for the period of observation.

FLATUS GASES AND RESPIRATORY METHANE AND HYDROGEN EXCHANGE
(from 1000 through 2200 hours)

Gemini	Menu	Subject	Days 40-42 Dry flatus gases, ml. Total	CO_2	O_2	N_2	CH_4	H_2	Respiratory Exchange, ml* CH_4	H_2
	II	0301	7	1	1	4	0	0	18	54
	I	0303	366	120	22	101	48	36	78	24
	I	0304	325	23	20	237	0	30	18	42
	III	0305	329	82	20	131	59	16	132	12
	II	0308	9	1	1	6	0	0	36	36
	III	0312	257*	54	14	112	0	51	30	24
		Ave.	216	47	13	99	18	22	52	32
Formula		0302	32	3	6	21	0	1	24	12
		0306	10	1	2	9	0	1	24	18
		0307	54	4	5	36	0	4	12	36
		0309	166	7	22	110	9	1	84	18
		0310	123	7	7	80	0	1	13	12
		0311	92	6	9	47	15	0	96	24
		Ave.	80	5	9	51	4	1	43	20

*Assumed pulmonary ventilation 500 liters per hour or 6×10^6 ml. for the period of observation.

I. Hematology and Blood Chemistry

The hematological findings are given in Tables 62, 63, 64a,64b. Data from Study #1 reveals little in the way of significant findings as does that of Study #2. In the latter, there was some slight tendency for decrease in hemoglobin with time in subjects 0202, 0203, 0204, and 0205. These changes were in no way related to dietary protein level. One elevation in white count was noted in subject 0206, and this was probably caused by mild upper-respiratory tract infection.

In Study #3 a small decline in hemoglobin concentration is noted in 4 of the Gemini group, but this is of doubtful significance. Elevation of white cell counts in subjects 0303 and 0312 on day 43 were due to mild upper-respiratory infection.

The blood chemistry findings are reported in Tables 65, 66, 67a,67b, 68a,68b.

All subjects receiving the formula showed a marked fall in serum cholesterol shortly after the formula was begun. This fall was greater in those exhibiting a higher cholesterol at the onset. Values remained low, even when protein was withdrawn from the diets; and low-protein or absence of protein appeared to have little effect on the cholesterol levels. There appeared to be a gradual rise in serum cholesterol levels with time in subjects on formula diets. However, after only 5 days of ingestion of normal food, all serum cholesterol levels rose significantly. The subjects receiving the Gemini diet exhibited a slight rise or no change in serum cholesterol levels.

In Studies 2 and 3 triglycerides were also determined. These levels were essentially unchanged except for one subject, 0303, who showed a progressive elevation of blood glucose level, serum glutamic pyruvic transaminase, and triglycerides during the period of Gemini diet feeding. He appeared to have developed a mild viremia about midpoint in the Study and following the Study his chemistries were normal. Nothing in this subject's history suggests a reason for the prediabetic-type response noted.

In Study #1 an increase in SGPT level is noted in all subjects, especially subjects 0103 and 0101. This tendency for elevation of SGPT was also noted in Study #2 in subjects 0205 and, particularly, 0206. The reason for the elevations in these individuals is uncertain. However, the SGPT is an extremely sensitive test of even mild alteration of hypatocellular function and elevations have been noted frequently in cases of individuals who are asymptomatic during the course of viral epidemics. It is possible that an asymptomatic virus infection was involved. There does not appear to be a consistent pattern observed in relation to dietary

HEMATOLOGIC FINDINGS

Subject	Day of Study	Hemoglobin g/100 ml	White Cells (cu.mm)	Segmented Cells %	Non-segmented Cells %	Lymphocytes %	Monocytes %	Eosinophils %	Basophils %
0101	Prestudy	15.0	10900	60	4	29	4	3	0
	2	16.0	10100						
	16	15.2	10000	49	1	44	4	2	0
	31	15.1	8900	45	0	3	7	3	0
	45*	15.9	7300	23	0	61	6	10	0
	60	16.1	5700	28	0	65	6	1	0
0102	Prestudy	16.8	7900	66	2	26	4	0	2
	2	16.8	5200						
	16	15.5	7500	57	0	41	2	0	0
	31	15.8	5600	47	0	50	3	9	1
	45	15.5	4800	44	0	50	3	3	0
	60	15.9	4800	59	0	34	6	1	0
0103	Prestudy	16.0	5400	65	0	19	10	5	1
	2	15.0	7000						
	16	13.5	6000	48	1	45	4	2	0
	31	14.0	5000	49	1	41	6	3	0
	45*	14.5	4400	41	1	55	2	1	0
	60	13.1	3300	32	0	60	4	4	0
0104	Prestudy	13.9	7300	52	0	38	7	2	1
	2	13.9	4600						
	16	12.3	5600	51	0	39	4	6	0
	31	12.8	6500	56	1	30	7	5	1
	45	13.4	4600	41	2	41	5	11	0
	60	11.9	2800	50	1	34	8	7	0

*"Zero" nitrogen intake.

Penthouse Study #2

HEMATOLOGIC FINDINGS

Table 63

Subject and Dietary Treatment*	Project Day	Haemo-globin	White Blood Cells (cu.mm)	Segment-ed Cells %	Non-seg-mented Cells %	Lympho-cytes %	Mono-cytes %	Eosino-phils %	Baso-phils %
0201									
Self-selected	prestudy	17.0	6800	56	1	29	8	6	0
Self-selected	02	16.3	6700	51	0	39	12	2	1
Control	14	16.8	5000	35	0	49	9	5	0
Control	32	16.4	6500	40	0	35	8	16	1
Control	50	16.3	5700	43	0	40	7	8	2
Control	67	15.6	5200	39	0	45	4	11	0
Control	84	16.2	4300	47	0	46	5	2	0
0202									
Self-selected	prestudy	14.5	6300	75	1	17	5	2	0
Self-selected	02	14.3	5000	66	1	28	4	1	0
Control	14	13.9	4900	49	1	42	8	0	0
Control	32	13.7	4100	55	0	37	7	1	0
Control	50	13.9	5400	51	0	38	9	2	0
Control	66	13.7	4400	57	0	39	4	0	0
Control	84	13.1	4100	51	0	47	1	1	0
0203									
Self-selected	prestudy	16.1	5100	57	0	30	7	4	2
Self-selected	02	16.1	4400	50	0	34	11	5	0
Control	14	15.8	3000	53	0	28	8	11	0
No protein	30	16.5	4400	48	0	35	6	10	1
Low protein	50	13.8	4000	44	1	41	9	5	0
Low protein	66	14.3	4000	45	0	44	5	6	0
Recovery	84	14.3	3000	55	0	42	1	2	0
0204									
Self-selected	02	16.3	4000	47	0	43	6	3	1
Control	14	15.0	4400	44	0	49	5	2	0
Low protein	32	13.9	4600	50	1	36	6	6	1
Recovery	50	14.8	5500	45	0	33	10	10	2
No protein	65	14.3	4500	37	0	49	4	8	2
Recovery	84	14.2	4000	51	0	35	6	6	2
0205									
Self-selected	01	12.7	3900	59	0	23	9	8	1
Control	14	13.3	3900	43	1	43	6	6	0
No protein	32	12.4	3600	41	0	37	9	12	1
Low protein	50	12.5	4200	35	2	43	9	9	2
Low protein	66	12.1	4200	45	0	44	5	6	0
Recovery	84	11.8	4300	48	0	45	2	5	0
0206									
Self-selected	prestudy	16.5	10700	70	1	23	2	2	2
Self-selected	02	16.3	7200	45	1	44	3	5	2
Control	14	16.9	6400	58	1	29	8	3	1
No protein	32	16.9	6500	48	0	44	5	3	0
Recovery	50	17.2	9600	50	0	31	13	5	1
Low protein	66	16.7	7600	60	0	28	9	9	3
Recovery	84	16.3	5900	57	0	34	4	5	0

*Samples obtained at the end of the indicated treatment period.

HEMATOLOGIC FINDINGS

Formula Subject	Day of Study	Hemo-globin g/100 ml	White cells per mm^3	Seg-mented %	Non-seg-mented %	Lympho-cytes %	Mono-cytes %	Eosino-phils %	Baso-phils %
0302	Prestudy	16.2	6300	69	0	22	5	3	1
	2	15.4	3700	58	0	35	3	3	1
	16	15.4	5400	60	0	36	4	0	0
	43	16.0	5800	53	0	39	6	2	0
0306	Prestudy	15.6	9300	61	6	19	11	2	1
	3	15.9	6600	49	0	44	7	0	0
	16	14.8	5000	53	0	38	5	4	0
	43	15.1	6800	46	0	44	6	4	0
0307	Prestudy	16.3	7900	72	0	21	4	2	1
	2	15.4	3400	54	0	37	5	2	0
	16	14.7	4800	58	0	37	3	2	0
	43	15.0	6600	49	0	38	7	5	1
0309	Prestudy	15.1	10200	67	0	23	5	4	1
	3	16.2	9000	58	0	28	9	3	2
	16	15.9	8500	50	0	41	6	3	0
	43	16.1	8200	60	0	28	10	2	0
0310	Prestudy	16.5	7000	63	0	32	4	1	0
	3	15.3	9400	61	1	29	9	0	0
	16	15.1	7000	72	0	22	5	0	1
	43	15.2	7100	48	0	48	4	0	0
0311	Prestudy	15.5	5700	68	0	25	4	2	1
	2	15.4	3700	46	0	38	14	2	0
	16	15.9	5000	50	0	44	4	2	0
	43	15.6	4900	46	0	39	10	4	1

continued

Penthouse Study #3
Hematologic Findings

Table 64b

Gemini Subject	Day of Study	Hemoglobin g/100 ml	White cells per mm^3	Segmented %	Non-segmented %	Lymphocytes %	Monocytes %	Eosinophils %	Basophils %
0301	Prestudy	16.0	7600	71	0	23	4	2	0
	3	15.6	6900	63	0	12	7	8	0
	16	15.6	6500	54	0	40	2	3	1
	43	15.1	7900	58	0	32	4	5	1
0303	Prestudy	15.5	7300	56	0	29	11	4	0
	3	14.4	6300	49	0	42	7	1	1
	16	14.2	5600	29	0	63	7	1	0
	43	13.3	12200	49	0	36	8	7	0
0304	Prestudy	15.5	8200	54	0	31	7	8	0
	2	15.4	5300	48	0	36	7	9	0
	16	15.8	7100	44	0	48	2	5	1
	43	15.6	7400	51	1	45	1	2	0
0305	Prestudy	16.0	10300	48	0	45	3	3	1
	3	16.3	8900	31	0	58	7	4	0
	16	15.0	7200	33	0	57	8	2	0
	43	14.8	9400	49	0	40	5	6	0
0308	Prestudy	16.4	7900	57	0	40	8	1	0
	3	15.9	6000	77	0	14	7	1	1
	16	15.1	6100	45	0	49	5	1	0
	43	15.3	6600	53	0	36	8	2	1
0312	Prestudy	16.0	10700	68	0	22	7	3	0
	2	16.3	6100	59	0	29	8	3	1
	16	15.4	7800	59	0	36	5	0	0
	43	16.8	10400	61	0	30	5	4	0

BLOOD CONSTITUENTS

Subject and Treatment*	Serum total protein gm/100 ml	Alpha 1 globulin %	Alpha 2 globulin %	Beta globulin %	Gamma globulin %	Albumin %	Urea nitrogen mg/100 ml	Uric acid mg/100 ml	Cholesterol mg/100 ml	Glucose** mg/100 ml	Protein-bound iodine mg/100 ml	Serum glutamic pyruvic transminase activity - Karmen units/ml	Bilirubin (total) mg/100 ml	Bilirubin (direct) mg/100 ml
Subject 0101														
Before Standardization	7.7	3.9	8.8	5.6	11.4	70.2	19.5	4.7	266	73	7.9	22	0.2	
Standardization I	6.7	2.2	9.5	6.2	13.9	68.2	14	3.3	174	70	6.7	8	0.4	0.2
Control II	6.6	4.2	11.4	8.3	11.1	64.9	16	3.6	167	72	6.7	37	0.4	
No Protein III	6.4	1.7	7.5	7.5	10.5	73.1	5	4.4	154	70	5.3	53	0.5	
Recovery IV	6.6	3.7	10.1	8.9	11.5	65.8	13	4.4	191	72	5.8	82	0.2	0.1
Subject 0102														
Before Standardization	7.2	2.0	8.1	6.9	12.8	70.6	15.5	5.1	182	65	5.6	136	0.4	
Standardization I	7.3	2.2	6.4	7.6	13.3	70.2	12.5	3.6	136	68	6.0	9	0.6	0.2
Control II	7.0	2.5	5.9	7.6	12.0	71.8	13	3.5	122	73	4.8	20	0.3	
Control III	6.7	3.0	7.9	7.9	11.9	70.5	13	3.9	134	75	5.8	30	0.3	
Control IV	7.2	2.1	6.0	6.3	12.1	73.4	14.5	4.1	152	72	5.1	36	0.5	0.1
Subject 0103														
Before Standardization	6.8	3.5	9.4	8.1	17.9	61.1	16	5.1	164	86	6.8	47	0.4	
Standardization I	6.6	3.1	7.7	7.9	17.5	63.6	15	3.7	110	71	5.2	15	0.4	0.1
Control II	6.4	3.1	8.5	7.9	17.6	63.0	14	3.6	110	71	5.6	57	0.2	
No Protein III	6.2	3.6	8.0	8.0	14.5	65.3	6	4.8	120	71	6.3	97	0.4	
Recovery IV	6.5	1.8	7.4	7.8	12.3	70.7	14	5.3	148	76	5.1	120	0.2	0.1
Subject 0104														
Before Standardization	7.3	3.1	8.1	7.8	11.8	69.0	17.5	4.6	215	77	6.2	22	0.4	
Standardization I	7.7	2.05	7.4	7.5	12.1	70.95	14.5	4.7	136	70	5.6	9	0.6	0.2
Control II	6.7	2.3	6.5	8.5	12.85	69.7	17.5	5.1	126	72	4.7	31	0.3	
Control III	6.6	3.1	7.5	8.1	10.3	70.9	16	5.2	140	75	4.0	40	0.3	
Control IV	6.8	3.3	7.7	8.7	10.8	69.7	16	5.6	156	78	5.1	46	0.5	0.1

*Samples taken at the beginning of the experiment and at the end of the indicated treatment periods.

**Whole blood; other values are for serum or plasma.

Penthouse Study #2

Table 66

BLOOD CONSTITUENTS

Subject and Treatment*	Day of Study	Total Protein g/100 ml	Urea mg/100 ml	Uric Acid mg/100 ml	Choles-terol mg/100 ml	Trigly-cerides mg/100 ml	Glucose mg/100 ml	Bilirubin (mg %) Total	Bilirubin (mg %) Direct	SGPT** (Karmen units)	PBI*** (µg %)
0201											
Self-selected	Prestudy		14	5.2	167		62			19	
Self-selected	02		20	5.5	159	87	81	0.3	0.1	27	4.6
Control	14	7.1	12	5.2	116	56	70	0.2	0.1	27	
Control	32	7.1	13	5.6	139	21	76	0.3	0.1	20	
Control	50	6.7	14	5.5	148	64	82	0.3		62	
Control	67	6.9	14	4.5	131	64	85	0.3		116	
Control	84	6.6	15	4.6	142	70	81	0.3		160	
0202											
Self-selected	Prestudy		16	5.2	214		76			52	
Self-selected	02		20	5.6	169	95	86	0.5	0.1	39	6.0
Control	14	6.7	14	5.1	146	86	77	0.2	0.1	36	
Control	32	6.5	14	5.6	170	96	84	0.2	0.1	15	
Control	50	6.4	13	5.2	167	95	85	0.3		25	
Control	66	6.6	15	4.4	160	66	83	0.4		25	
Control	84	6.5	15	5.4	166	79	78	0.4		21	
0203											
Self-selected	Prestudy		15	5.0	184		91			23	
Self-selected	02		25	5.7	173	86	86	0.6	0.1	21	4.9
Control	14	5.9	17	5.4	128	54	78	0.5	0.1	18	
No protein	30	6.6	06	5.9	170	89	75	0.6	0.3	16	
Low protein	50	6.0	08	4.9	156	73	82	1.4		30	
Low protein	66	6.2	10	5.3	156	76	84	0.5		37	
Recovery	84	6.1	20	4.3	145	68	79	0.9		14	
0204											
Self-selected	02		16	5.0	138	65	80	0.3	0.1	20	3.8
Control	14	6.4	15	4.2	128	61	76	0.5	0.1	24	
Low protein	32	6.2	06	5.1	156	88	77	0.5	0.1	21	
Recovery	50	6.4	13	3.7	154	65	83	0.7		25	
No protein	65	6.3	05	5.2	130	47	80	0.5		24	
Recovery	84	6.5	12	3.4	150	52	77	0.5		23	

continued

Penthouse Study #2 Blood Constituents

Table 66 continued

Subject and Treatment*	Day of Study	Total Protein g/100 ml	Urea mg/100 ml	Uric Acid mg/100 ml	Choles-terol mg/100 ml	Trigly-cerides mg/100 ml	Glucose mg/100 ml	Bilirubin (mg %) Total	Bilirubin (mg %) Direct	SGPT** (Karmen units)	PBI*** (μg %)
0205											
Self-selected	01		22	5.6	202	81	82	0.3	0.1	33	
Control	14	6.4	16	4.9	148	67	75	0.1	0.1	20	4.5
No protein	32	6.4	08	7.3	172	76	82	0.1	0.1	30	
Low protein	50	6.6	09	5.8	169	75	84	1.0		58	
Low protein	66	6.2	08	6.2	157	61	81	0.2		76	
Recovery	84	6.5	17	5.2	153	59	75	0.4		64	
0206											
Self-selected	Prestudy		11	4.3	166		74			21	
Self-selected	02		17	5.0	136	74	80	0.2	0.1	22	
Control	14	6.7	11	4.6	117	118	72	0.2	0.1	22	4.8
No protein	32	6.6	02	6.2	136	88	70	0.3	0.2	46	
Recovery	50	6.6	11	3.9	168	115	82	0.3		174	
Low protein	66	6.8	08	4.7	156	96	74	0.1		249	
Recovery	84	6.5	12	4.3	148	76	74	0.6		110	
Average											
Control Per I (N=6)****		6.5	14	4.9	130						
No protein (N=4)		6.5	5	6.2	152(C150)						
Low protein (N=6)		6.3	8	5.3	158(C152)						
Recovery (N=6)		6.4	14	4.1	153(C156)						
Self-selected (N=6)					163						

*Samples taken at the beginning of the experiment and at the end of the indicated treatment periods.

**Serum glutamic pyruvic transminase activity.

***Protein-bound iodine.

****N = No. of subject periods.

Penthouse Study #3

Table 67a

SERUM NITROGENOUS AND LIPID COMPONENTS, PBI, TRANSAMINASE AND BLOOD GLUCOSE

Formula Subject	Day of Study	Total Protein g/100 ml	Urea Nitrogen g/100 ml	Uric Acid g/100 ml	Total Cholesterol mg/100 ml	Tri-glycerides mg/100 ml	Glucose mg/100 ml	Protein-Bound Iodine mcg/100 ml	Glutamic-pyruvic Transaminase activity Karmen Units/ml
0302	Prestudy	6.9	15	4.8	161		80	4.9	29
	2	6.5		6.3	175	63			20
	16	6.4		5.5	114	36	76		17
	43	6.0	13	4.3	118	29	70		
0306	Prestudy	8.0	14	4.9	146		80	3.8	50
	3	6.9		5.3	154	65			34
	16	6.8		4.9	116	58	85		28
	43	6.6	14	4.3	122	47	82		26
0307	Prestudy	7.6	15	4.3	188		81	5.6	26
	2	6.6		4.8	186	51			22
	16	6.6		3.6	134	61	79		25
	43	5.8	13	3.7	138	60	79		25
0309	Prestudy	7.8	15	4.4	190		91	5.9	22
	3	7.1		5.1	180	51			20
	16	7.3		4.2	134	47	72		16
	43	7.1	16	4.4	146	49	75		14
0310	Prestudy	8.0	19	5.5	182		80	6.6	32
	3	7.1		4.3	166	48			26
	16	6.8		4.4	172	104	83		30
	43	6.8	13	4.1	182	87	80		54
0311	Prestudy	6.9	16	4.8	176		82	4.8	23
	3	6.4		5.5	188	61			22
	16	6.4		4.1	154	62	81		18
	43	6.0	13	3.7	158	59	80		12
Avg.	2-3	6.8	16	5.2	175	56	82**	5.3**	24
	43	6.4	14	4.1	144	55	78		26

continued

Table 67b

Penthouse Study #3
Serum Nitrogenous and Lipid Components, PBI,
Transaminase and Blood Glucose

Gemini Subject	Day of Study	Total Protein g/100 ml	Urea Nitrogen g/100 ml	Uric Acid g/100 ml	Total Cholesterol mg/100 ml	Tri-glycerides mg/100 ml	Glucose mg/100 ml	Protein-Bound Iodine mcg/100 ml	Glutamic-Pyruvic Transaminase Activity - Karmen Units/ml
0301	Prestudy	8.0	15	4.4	174		84	4.9	20
	3	7.1		5.4	191	67			20
	16	7.4		5.7	234	75	84		26
	43	6.6	13	6.1	226	65	73		24
0303	Prestudy	7.7	13	4.4	156		90	4.8	38
	3	7.3		5.9	186	120			40
	16	7.0		6.0	190	112	97		52
	43	6.6	11	5.6	172	170	126*		225*
0304	Prestudy	7.8	16	5.0	196		88	5.5	22
	2	7.0		6.1	196	95			21
	16	6.8		5.8	200	93	91		19
	43	6.2	17	5.4	206	95	91		17
0305	Prestudy	7.0	17	4.5	190		83	6.0	28
	3	6.9		5.4	203	70			22
	16	6.6		5.4	220	71	88		23
	43	6.3	16	4.8	228	94	84		22
0308	Prestudy	7.1	12	4.4	158		79	5.1	46
	3	6.4		5.1	143	45			29
	16	6.4		5.3	150	54	80		22
	43	5.6	14	4.1	141	41	77		24
0312	Prestudy		14	3.4	190		107	5.7	30
	2	6.9		4.8	200	83			23
	16	6.1		4.3	206	73	79		28
	43	6.3	15	3.8	222	88	79		18
Avg.	2-3	6.9	14**	5.4	186	80	89**	5.3**	26
	43	6.3	14	5.0	199	92	88		21+

*Follow-up post-study showed 104 mg % blood glucose (fasting) [illegible] SGPT.
+Subject 0303 omitted.
**Pre-test averages.

SERUM MINERALS

Formula Subject	Day of Study	Sodium mEq/liter	Potassium mEq/liter	Chloride mEq/liter	Calcium mEq/liter	Magnesium mEq/liter	Phosphorus mM/liter
0302	2	145	4.0	100	4.6	1.8	1.3
	16	143	4.0	100	4.9	2.0	1.4
	43	143	3.5	103	4.9	1.7	
0306	3	137	3.8	100	4.8	1.8	1.2
	16	141	4.3	101	5.0	1.8	1.2
	43	142	3.6	103	5.1	1.7	
0307	2	143	4.1	98	5.0	1.7	1.3
	16	145	4.1	100	5.0	1.7	1.2
	43	144	4.1	103	4.9	1.6	
0309	3	143	4.7	98	5.2	2.0	1.4
	16	143	4.1	97	5.1	1.7	1.2
	43	144	3.5	103	5.3	1.7	
0310	3	142	3.5	99	4.9	1.6	1.3
	16	145	3.4	96	5.0	1.6	1.2
	43	144	3.3	100	5.1	1.6	
0311	2	146	3.8	104	4.6	1.7	.9
	16	145	4.0	97	4.8	1.8	1.0
	43	145	3.8	101	4.9	1.7	

continued

Table 68b

Gemini Subject	Day of Study	Sodium mEq/liter	Potassium mEq/liter	Chloride mEq/liter	Calcium mEq/liter	Magnesium mEq/liter	Phosphorus mM/liter
0301	3	143	4.2	103	5.0	1.7	1.1
	16	141	3.8	97	5.0	1.8	1.2
	43	143	3.7	102	5.0	1.8	
0303	3	139	3.9	99	4.8	1.7	1.2
	16	145	4.0	99	4.8	1.6	1.1
	43	139	3.8	101	4.8	1.6	
0304	2	141	6.3	102	4.8	1.7	1.4
	16	145	3.5	102	4.9	1.8	1.3
	43	141	3.0	102	4.9	1.8	
0305	3	144	4.2	101	5.1	1.7	1.4
	16	143	3.6	100	5.1	1.6	1.1
	43	142	3.5	103	5.1	1.7	
0308	3	144	4.0	101	4.7	1.8	1.3
	16	143	4.0	101	4.8	1.7	1.1
	43	144	3.9	103	4.8	1.7	
0312	2	142	4.1	102	4.7	1.8	1.1
	16	145	3.9	99	4.7	1.7	1.2
	43	144	3.4	102	5.1	1.9	

regimen. In Study #3 no significant alteration in SGPT was noted except for subject 0303, discussed above.

The most noticeable and consistent change on alterations of protein intake was the marked decrease in urea nitrogen during zero and low protein intake. The average values fell from about 14 mg/100 ml to about 5 mg/100 ml. The low-protein diet resulted in an intermediate level of about 8 mg/100 ml. This response of blood urea to dietary protein alteration has been known for many years. It was interesting to note, as discussed previously, that this drop correlated well with the decreased nitrogen loss through the skin. There appeared to be some slight correlation between protein level and serum uric acid. The serum uric acids seemed to be highest during the no-protein level, slightly lower during low-protein intake, and lowest during the control or recovery phases. The serum total protein did not appear to vary with changes in dietary protein level.

In Study #1 electrophoretic fractionation of the proteins was carried out, and there was no change in any of the fractions which could be attributed to the lack of protein. In view of the negative findings in this group, further electrophoretic analyses were not carried out.

In Study #3 when sodium, potassium, chloride, calcium, magnesium, and phosphorus were measured they were normal in all subjects at all times in the Study and did not differ between groups.

J. Basal Metabolic Rates

The basal metabolic rates were determined in Studies 1 and 2 and are shown in Tables 69 and 70.

There seems to be considerable variation when the same subject is reexamined. It was very difficult to maintain true basal conditions, and therefore this finding is not unexpected. The results fall within the normal range for all subjects.

BASAL METABOLIC RATE

Subject 0102

Period III	79.41 Kcal/hr. 42.1 Kcal/hr./M^2 + 7%
Period IV	72.52 Kcal/hr. 37.2 Kcal/hr./M^2 -2%

Subject 0104*

Period III	83.72 Kcal/hr. 41.4 Kcal/hr./M^2 +2%

Subject 0103

Period III	61.5 Kcal/hr. 36.2 Kcal/hr./M^2 -10%
Period IV	63.3 Kcal/hr. 37.2 Kcal/hr./M^2 -12%

Subject 0101*

Period III	72.80 Kcal/hr. 41.8 Kcal/hr./M^2 +4%

*Data for Period IV are not available.

BASAL METABOLIC RATE

Subject	Kilocalories/Square Meter Body Surface/Hour Metabolic Periods					
	Beginning	1 *	2 *	3 **	4 **	5 **
0201	45.6	39.5	32.5	45.4	44.9	42.3
0202	49.4	38.7	42.1	45.0	40.5	46.5
0203	40.6	40.0	35.4	47.9	43.5	51.1
0204	----	40.3	36.0	37.7	43.7	50.0
0205	48.6	39.0	31.1	43.2	50.5	44.1
0206	40.4	37.8	39.3	48.3	50.1	50.0

* Benedict-Roth apparatus
** Sanborn apparatus

K. Physical Fitness

Physical fitness was evaluated by the physical work capacity as measured by bicycle ergometer tests, by tilt table response, and by muscle strength. During the bicycle ergometry tests, electrocardiograph records were taken at each level of work. These at all times were consistently normal. During Studies 1 and 2 the physical work capacity was evaluated only by determining the heart rate during bicycle work. In Study #3 the technique had been developed for evaluating ventilation rate, oxygen consumption, and energy expenditure. The subjects entered the Studies in varying states of physical condition, and their performances tended to reflect this state. There appeared to be no significant alteration of conditioning during the total experimental period.

During Studies 1 and 2 work on the bicycle ergometer evoked maximal attainable heart rates (Tables 71 and 72). The work load which resulted in this maximum bore no relationship to the dietary nitrogen intake. During Study #3 evaluation of maximal oxygen uptake revealed that the work task exceeds the maximal oxygen uptake for most subjects, and oxygen debt is accumulated (Table 73a,73b).

Cardiovascular response to tilting did not discriminate between dietary treatments and showed no significant change with time in the course of the experiment (Tables 74, 75, 76a,76b). There appeared to be no differences between the Gemini and formula-fed subjects in spite of some variation in sodium intake.

Tables 77, 78, and 79 show the studies in muscular strength. Here again, there is no correlation noted between dietary treatment or duration of the experiment and muscle strength. Wide variations are noted in this test, as would be expected, since motivation plays such an important role in its performance.

In Table 80 is shown the ammonia and lactic acid level of the blood before and after standard bicycle ergometer tests in Study #3. Here again there is considerable variation between individuals noted in both blood lactate and ammonia levels, particularly in response to exercise. The expected rise in blood lactic acid, seen in individuals undergoing heavy work loads where the maximal oxygen uptake is exceeded, was recorded. The changes in blood ammonia are likewise similar to those that had been reported. It is rather interesting to note that 2 of the subjects in the Gemini group who were apparently not very physically fit and did not complete the ergometer test revealed changes in both blood ammonia and lactic acid response to exercise which were no different from those who completed the test and appeared to be in much better condition. It therefore appears that this test cannot serve as a particularly good prognosticator of physical fitness.

HEART RATES DURING BICYCLE WORK
(Beats per Minute)

	Standardization I	Test Period A II	Test Period B III	Recovery IV
Subject 0102				
Dietary Treatment*	12.7	13.2	13.3	13.6
Average rest	68	70	80	80
Min. 5-6 at 450 kgm/m	--	120	112	117
Min. 5-6 at 900 kgm/m	148	160	159	152
Min. 5-6 at 1200 kgm/m	174	178	180	178
Subject 0104				
Dietary Treatment*	12.7	13.2	13.3	13.6
Average rest	63	65	68	70
Min. 5-6 at 450 kgm/m	114	108	110	105
Min. 5-6 at 900 kgm/m	176	168	165	147
Min. 5-6 at 1200 kgm/m	--	186	185	180
Subject 0103				
Dietary Treatment*	12.7	13.2	0.62	13.7
Average rest	93	97	95	76
Min. 5-6 at 450 kgm/m	150	126	132	129
Min. 5-6 at 900 kgm/m	172	178	178	169
Min. 5-6 at 1200 kgm/m	--	208	200	190
Subject 0101				
Dietary Treatment*	12.7	13.2	0.62	13.7
Average rest	116	120	127	120
Min. 5-6 at 450 kgm/m	--	161	154	150
Min. 5-6 at 900 kgm/m	191	190	193	190
Min. 5-6 at 1200 kgm/m	--	190	200	203
Ave., 4 subjects:				
Average rest	85	88	92.5	86.5
Min. 5-6 at 450 kgm/m	--	139	127	125
Min. 5-6 at 900 kgm/m	172	174	174	164.5
Min. 5-6 at 1200 kgm/m	--	190.5	191	188

*Grams nitrogen/day

BICYCLE ERGOMETRY
PULSE RATE PER MINUTE

Subject	Dietary Treatment	Day	Rest	450	900	1200
0201	C	11	68	108	151	168
		18	72	104	155	176
		29	58	104	151	176
		42	72	108	159	182
		54	76	110	164	188
		66	80	120	168	192
		78	90	112	156	184
		87	80	116	150	184
0202	C	11	68	113	158	191
		18	88	120	168	186
		29	96	118	165	184
		42	94	124	171	184
		54	68	112	164	188
		66	80	112	172	184
		78	80	112	168	200
		87	74	108	162	200
0203	C	11	58	92	160	214
	O	18	--	96	146	176
	O	29	58	92	140	178
	low	42	54	99	154	194
	low	54	84	120	176	224
	low	66	54	104	164	200
	R	78	56	100	164	192
	R	87	74	104	160	196
0204	C	11	73	122	159	180
	low	18	80	112	158	188
	low	29	76	125	164	184
	R	42	90	131	176	189
	O	54	96	132	166	200
	O	66	94	124	176	208
	R	78	90	128	176	198
	R	87	76	114	168	196
0205	C	11	61	90	145	153
	O	18	--	96	130	159
	O	29	68	106	135	175
	low	42	65	102	158	178
	low	54	78	114	164	182
	low	66	54	94	156	189
	R	79	--	112	176	192
	R	87	68	114	166	188

continued

Penthouse Study #2
Bicycle Ergometry Pulse Rate Per Minute

Table 72
continued

Subject	Dietary Treatment	Day	Rest	450	900	1200
0206	C	11	110	141	---	---
	O	18	---	136	176	---
	O	29	---	136	176	---
	R	42	80	133	180	188
	low	66	92	144	188	---
	R	78	88	152	---	---
	R	87	90	144	---	---

Table 73a

CARDIAC AND PULMONARY RESPONSE TO STANDARD BICYCLE ERGOMETER TEST

Formula Subject		Ventilation Rate l/min.				Oxygen Consumption ml/min.				Pulse Rate Beats/min.				Energy Expenditure Kcal/min.			
		R	450	900	1200	R	450	900	1200	R	450	900	1200	R	450	900	1200
0302	a	--	30.0	--	--	--	--	--	--	76	85	125	150	--	--	--	--
	b	15.1	29.7	52.6	68.5	463	1519	2577	3412	110	110	132	162	2.4	7.4	12.8	17.0
	c	14.7	31.8	50.2	69.3	360	1009	2135	2874	73	102	130	162	1.8	5.2	10.8	15.8
	d	17.3	34.5	54.5	82.8	385	1183	2092	2972	72	96	128	170	1.9	5.9	10.6	15.3
0306	a	14.8	30.7	50.7	70.9	468	1293	2317	2942	87	108	140	160	2.3	6.4	11.6	15.1
	b	13.0	30.9	55.4	78.8	310	1121	2182	3120	78	100	139	173	1.6	6.2	11.3	16.3
	c	12.8	33.0	42.9	84.5	329	1176	1844	3015	73	102	149	174	1.6	5.8	9.7	16.1
	d	14.2	28.4	54.4	**	382	1252	2406	--	102	118	168	--	1.9	6.1	8.7	--
0307	a	14.3	36.8	77.7	124.0	320	1258	2564	2742	100	142	176	182	1.7	6.5	13.6	15.2
	b	11.2	33.2	64.3	**	310	1181	2245	--	115	152	180	--	1.6	6.0	11.6	--
	c	11.1	32.2	81.4	108.6	275	1087	2303	2530	128	145	185	187	1.4	5.9	13.2	14.1
	d	12.9	32.9	70.3	112.1	314	1110	2270	2848	128	150	187	200	1.6	5.3	12.0	15.2
0309	a	12.0	33.6	76.0	**	331	1184	2258	--	94	115	162	--	1.7	5.9	11.6	--
	b	12.4	36.5	84.3	119.0	331	1190	2328	2846	105	132	174	178	1.6	6.1	12.5	15.4
	c	13.5	34.3	71.0	125.5	327	1113	2024	2910	95	119	166	180	1.7	5.9	11.2	16.1
	d	15.5	36.5	72.8	128.0	419	1179	2090	3047	108	110	170	182	2.1	6.3	11.0	16.5
0310	a	9.7	23.4	37.4	--	320	829	1726	1804	88	118	140	152	1.6	5.2	8.6	--
	b	12.7	28.2	41.8	57.7	330	1184	1806	2343	86	115	148	170	1.7	6.0	9.7	11.9
	c	13.3	23.4	45.6	68.3	344	1051	1862	2295	--	--	--	--	1.8	5.3	9.8	12.4
	d	11.8	25.1	50.2	70.1	373	1028	1967	2308	82	100	154	172	1.9	5.2	10.1	12.3
0311	a	25.5	37.2	72.4	124.9	--	1267	2041	2610	94	112	148	174	2.4	6.5	11.2	14.1
	b	25.5	36.1	66.5	119.5	423	1158	2102	2724	84	98	142	174	2.1	6.1	11.1	14.8
	c	19.7	31.9	61.2	146.7	--	1105	2019	2905	--	--	--	--	1.6	5.7	10.7	15.3
	d	17.0	33.9	64.0	143.5	335	1134	2060	2869	87	114	148	175	1.8	5.7	10.7	15.5

continued

Penthouse Study #3

Table 73b

Cardiac and Pulmonary Response to Standard Bicycle Ergometer Test

Gemini Subject		Ventilation Rate l/min.				Oxygen Consumption ml/min.				Pulse Rate Beats/min. Incr. after				Energy Expenditure Kcal/min.			
		R	450	900	1200	R	450	900	1200	R	450	900	1200	R	450	900	1200
0301*	a	11.7	35.6	76.0	**	266	1218	1983	--	98	145	190	--	1.3	6.1	10.4	--
	b	14.8	35.5	82.6	**	302	1221	2229	--	108	152	190	--	1.5	6.3	11.8	--
	c	19.0	32.3	83.3	**	--	1084	3123	--	104	135	195	--	2.7	5.9	15.2	--
	d	11.4	34.9	81.5	101.8	369	1285	2283	2574	103	120	195	195	1.8	6.4	12.0	13.1
0303	a	12.5	29.5	45.0	86.1	393	1296	2023	3933	90	127	175	200	1.8	6.2	9.9	18.9
	b	12.3	--	51.1	76.2	317	--	2000	2650	83	124	128	190	1.5	--	10.2	13.9
	c	12.5	31.2	55.3	75.8	347	1156	2195	2586	104	125	170	190	1.6	5.9	11.2	14.5
	d	11.9	31.5	52.5	85.3	302	1157	2019	2790	75	122	158	185	1.5	5.9	10.6	15.2
0304	a	12.9	--	62.8	82.2	425	--	2360	3042	78	114	160	187	2.0	--	12.0	15.4
	b	12.5	32.3	49.9	75.4	361	1275	2161	2646	81	138	152	186	1.8	6.3	10.9	13.9
	c	10.4	32.3	55.0	74.6	334	1220	2167	2767	94	122	170	187	1.6	6.2	11.2	14.5
	d	12.6	32.3	49.8	62.2	326	1150	2000	2470	80	118	140	170	1.6	5.8	10.3	12.8
0305	a	11.2	24.0	41.0	49.2	325	1010	1892	2359	98	115	170	178	1.6	4.8	9.2	11.6
	b	5.7	22.8	39.9	62.4	308	1304	2056	2695	70	115	148	180	1.5	6.3	10.3	13.8
	c	12.4	29.2	49.7	63.7	537	1128	2251	2750	87	128	150	182	1.8	6.1	10.9	13.4
	d	9.6	27.6	47.0	65.4	300	1162	2006	2755	94	105	150	175	1.5	5.8	10.4	14.4
0308	a	23.9	35.3	--	--	--	1239	--	--	86	112	162	180	2.3	6.3	--	--
	b	24.2	39.7	73.7	131.0	--	1271	2372	3026	70	94	--	--	2.0	6.5	12.3	16.1
	c	18.7	38.1	76.7	122.0	425	1177	2392	2927	--	--	--	--	2.1	6.3	12.7	16.0
	d	26.7	38.9	76.8	131.9	--	1205	2379	2981	95	115	162	175	2.4	6.2	12.4	16.2
0312	a	11.8	31.4	54.2	85.5	368	--	2115	2308	97	119	155	180	1.8	5.9	10.5	11.5
	b	14.4	29.2	62.3	90.8	432	1170	2135	2541	--	118	160	170	2.2	5.9	11.3	13.7
	c	11.4	29.5	65.0	**	313	1112	2209	--	--	--	--	--	1.6	5.6	11.6	T
	d	11.6	33.6	77.6	**	331	1187	2335	--	98	135	155	--	1.6	6.0	12.2	T

*Tests administered on study days: a, 3-5; b, 16-18; c, 29-31; and d, 42-44.

**Unable to complete test.

CARDIOVASCULAR RESPONSE TO TILT TABLE TEST

Subject	Period	Flat (0°) Blood Pressure mm Hg	30° Blood Pressure mm Hg	60° Blood Pressure mm Hg	60° Pulse	60° Respiration	90° Blood Pressure mm Hg	Off (0°) Blood Pressure mm Hg	Off (0°) Pulse	Off (0°) Respiration
0101	I [a]	116/70	116/74	110/74			98/80	114/92		
	II [b]	126/78	122/76	124/76			122/74	115/70	98	
	III [c]	120/80	116/78	104/80	120	20	114/76	116/76	144	20
	IV [d]	124/74	127/80	125/80	96	20	120/82	124/80	120	20
0102	I [a]	120/60	120/62	120/66			122/70	122/74		
	II [b]	128/80	120/74	124/74	72	16	130/80	132/82		
	III [e]	122/70	118/70	120/72	80	20	122/74	120/74	88	20
	IV [f]	132/90	128/86	124/86	75	16	126/86	124/86	96	18
0103	I [a]	104/62	104/70	104/72			100/70	100/72		
	II [b]	120/68	118/70	110/70	110	18	112/70	108/68	88	16
	III [c]	124/68	120/68	118/68	124	18	110/60	116/64	160	18
	IV [d]	120/70	118/74	118/80	74	16	118/80	116/78	96	18
0104	I [a]	108/58	102/58	104/62			104/60	102/60		
	II [b]	100/60	100/64	102/70			110/74	104/70		
	III [e]	112/54	104/60	110/64	66	12	110/64	108/64	80	16
	IV [f]	110/58	108/60	100/62			104/54	106/60		

Dietary Treatment (g nitrogen/day):
[a]12.7; [b]13.2; [c]0.62; [d]13.7; [e]13.3; [f]13.6

CARDIOVASCULAR RESPONSE TO TILT TABLE TEST

		0°			30°	60°			90°	0°		
Subject	Day	Blood Pressure	Pulse	Respiration	B.P.	B.P.	P.	R.	B.P.	B.P.	P.	R.
0201	02	120/80	70	12	116/76	120/80	88	16	120/82	118/84		
	13	104/74	54	12	112/72	108/70	72	16	112/72	108/70	84	16
	32	108/70	60	12	106/68	104/64	84	12	104/68	100/64	84	20
	50	118/70	60	12	112/70	108/70	90	15	108/72	112/70	100	18
	65	118/72	68	12	118/74	112/72	78	15	110/70	110/68	90	15
	77	124/70	76	12	118/74	116/74	108	15	116/70	114/72	130	18
	86	140/72	80	16	136/74	130/70	104	16	136/72	130/70	98	16
0202	02	144/68	96	12	140/80	140/90	112	16	130/90	136/90		
	15	138/76	68	12	132/82	138/80	120	15	134/84	130/80	104	16
	32	124/70	84	12	128/70	130/80	104	16	128/78	130/78	104	16
	50	130/70	72	12	120/74	122/76	80	12	128/80	136/84	78	12
	65	128/74	72	12	128/74	130/78	84	15	128/82	132/84	80	15
	77	110/68	60	12	118/72	116/70	80	16	118/72	122/74	96	18
	85	130/84	66	12	132/80	132/76	76	15	132/80	136/80	84	15
0203	02	110/60	50	12	112/58	108/60	78	12	110/60	108/58		
	15	100/56	48	12	110/60	106/60	60	12	100/58	98/60		
	32	112/60	48	12	108/64	104/68	70	12	106/64	108/66		
	50	110/54	50	12	108/54	106/60	90	15	108/64	106/64	80	15
	65	108/60	54	15	104/60	104/64	80	15	110/70	108/74	84	15
	77	112/60	60	12	108/60	106/64	78	15	112/64	110/60	84	15
	86	110/58	60	15	112/60	108/60	76	20	110/64	108/70	80	20
0204	02	112/60	68	16	110/60	108/66	34	16	112/70	110/70		
	15	130/70	72	14	110/68	114/72	96	14	116/70	114/70	120	16
	32	124/70	72	12	120/72	112/72	92	14	118/76	122/80		
	50	122/70	72	12	118/72	120/76	38	12	122/80	120/84	120	15
	65	128/80	64	18	118/74	120/80			120/80	118/78	108	18
	77	134/72	78	15	126/72	124/72	100	20	120/74	118/74	126	20
	86	130/80	78	12	124/70	132/80	38	15	122/74	120/72	93	15

Continued

		0°			30°	60°			90°	0°		
Subject	Day	Blood Pressure	Pulse	Respiration	B.P.	B.P.	P.	R.	B.P.	B.P.	P.	R.
0205	03	98/58	60	18	98/60	102/60	62	15	100/60	102/58		
	15	108/54	52	12	108/58	106/58	72	16	108/58	104/60	90	16
	32	102/56	58	12	102/60	100/64	60	12	98/64	102/60	75	15
	50	104/50	60	12	96/50	92/54	92	15	92/60	90/58	90	15
	65	104/50	60	12	100/54	94/52	72	15	98/60	96/60	72	15
	77	118/54	76	12	114/58	112/60	96	18	108/60	102/58	120	18
	86	112/66	72	12	110/66	110/60	96	15	110/64	108/60	132	15
0206	02	132/72	80	12	132/68	128/64	96	16	126/60	126/60		
	15	150/72	76	12	146/72	148/68	96	16	146/64	148/64		
	32	130/76	96	18	130/80	130/78	108	18	128/80	126/78	116	18
	50	136/68	76	12	132/70	130/72	96	15	134/74	128/74	96	15
	65	140/72	90	15	144/76	140/70	120	18	144/76	148/74	130	18
	77	128/72	88	18	124/80	130/80	108	18	130/80	128/74	110	20
	86	140/70	84	15	142/64	142/64	88	15	142/66	142/66	96	15

CARDIOVASCULAR RESPONSE TO TILT TABLE TEST

Response to Tilt Angle

Formula Subject	Day of Study	0° Blood Pressure mm Hg	0° Rate/min. Pulse	0° Rate/min. Resp.	30° B.P.	60° B.P.	60° P.	60° R.	90° B.P.	0° B.P.	0° P.	0° R.
0302	10	108/70	66	18	104/70	100/68	82	18	98/68	104/70	88	18
	23	100/70	68	18	106/70	112/70	92	18	110/68	108/70	104	18
	37	102/64	74	18	100/60	100/60	88	18	98/58	102/60	96	16
0306	10	110/74	76	18	112/68	112/70	100	20	110/66	110/66	100	20
	23	110/66	66	16	104/70	100/68	76	18	98/66	96/66	80	18
	37	108/58	70	18	108/60	104/60	92	18	100/58	104/60	96	18
0307	9	120/64	60	18	124/60	124/64	78	18	120/60	118/58	96	18
	22	116/70	66	18	122/70	120/72	72	18	118/70	116/70	88	16
	37	130/60	72	18	132/62	128/60	104	20	124/60	126/60	110	20
0309	9	130/72	66	18	120/74	120/78	104	20	122/80	120/76	110	18
	22	134/68	78	18	128/68	124/66	86	16	122/70	120/70	92	18
	37	124/16	66	18	118/60	112/60	80	18	112/60	110/58	84	18
0310	10	110/60	60	18	116/64	114/66	84	18	112/70	112/72	84	18
	23	118/60	60	18	122/68	118/64	72	18	114/60	118/62	92	18
	37	114/64	--	--	114/60	114/60	--	--	114/60	114/60	100	16
0311	10	118/74	76	20	116/76	116/76	84	20	118/80	118/78	80	20
	22	118/70	84	18	118/72	122/74	92	18	120/76	122/70	92	18
	39	112/70	80	16	108/68	106/70	92	16	110/72	110/70	110	20

continued

Penthouse Study #3
Cardiovascular Response to Tilt Table Test

Table 76b

					Response to Tilt Angle							
Gemini Subject	Day of Study	0° Blood Pressure mm Hg	0° Rate/min. Pulse	0° Rate/min. Resp.	30° B.P.	60° B.P.	60° P.	60° R.	90° B.P.	0° B.P.	0° P.	0° R.
0301	10	104/62	72	18	104/64	102/70	90	18	98/70	104/68	108	18
	20	100/68	80	16	98/70	102/72	96	16	100/70	100/70	118	16
	37	114/60	72	18	112/60	110/60	100	18	108/60	108/60	110	20
0303	9	130/80	70	18	132/84	130/80	72	18	130/84	130/80	72	18
	22	130/78	80	16	132/80	130/78	76	18	132/76	128/80	88	18
	37	142/76	54	18	138/78	140/76	84	18	142/74	140/76	88	18
0304	9	110/70	72	18	108/72	108/72	92	18	108/76	110/74	100	18
	23	116/76	76	18	120/74	120/74	90	18	116/72	114/72	90	18
	37	122/70	60	12	116/68	112/70	84	18	110/68	108/70	90	12
0305	10	122/74	66	18	118/72	116/70	80	18	118/70	116/72	78	18
	23	110/70	70	18	106/68	108/70	84	16	106/68	106/70	92	16
	39	112/54	72	16	110/60	112/60	84	16	110/58	100/60	100	18
0308	10	132/54	66	18	120/58	118/62	100	18	115/60	112/62	104	18
	23	124/58	72	16	122/58	122/60	98	18	122/60	120/60	104	18
	37	104/60	50	18	104/60	108/60	100	18	104/58	102/58	103	18
0312	9	140/70	80	20	138/70	138/74	84	20	138/76	142/76	90	20
	23	134/72	80	16	130/70	132/72	84	16	128/70	130/70	92	16
	39	132/68	72	14	132/70	134/72	100	16	138/78	140/78	108	16

MUSCULAR STRENGTH IN KILOGRAMS

	Standardization I	Test Period II	Test Period III	Recovery IV
Subject 0102				
Left Grip	51	54	55	55
Right Grip	52	53	54	54
Leg Strength	215	245	260	248
Back Strength	190	200	200	190
Subject 0104				
Left Grip	54	55	57	55
Right Grip	58	64	67	66
Leg Strength	215	260	210	290
Back Strength	150	140	150	150
Subject 0103				
Left Grip	50	49	55	47
Right Grip	57	57	62	61
Leg Strength	305	320	315	290
Back Strength	150	170	145	145
Subject 0101				
Left Grip	36	45	41	47
Right Grip	46	47	43	37
Leg Strength	205	197	168	195
Back Strength	130	120	120	120
Ave., 4 subjects:				
Left Grip	48	51	52	51
Right Grip	53	57	57	55
Leg Strength	235	256	238	256
Back Strength	155	153	153	151

MUSCULAR STRENGTH IN KILOGRAMS

Subject		Project Day of Strength Tests								
		6	11	18	29	42	54	66	78	87
0201	left	48	*-	54	49	55	52	54	50	52
	right	60	-	56	56	64	60	60	59	60
	legs	230	-	250	190	185	130	225	220	250
	back	140	-	165	120	172	170	160	160	180
0202	left	57	58	54	58	55	55	55	55	59
	right	56	57	50	57	54	55	53	53	58
	legs	150	212	220	210	190	215	230	185	180
	back	160	176	180	182	170	165	170	175	185
0203	left	58	58	56	54	51	49	50	51	54
	right	60	60	61	57	61	53	54	53	54
	legs	200	254	275	260	259	235	290	230	250
	back	148	150	165	170	163	155	160	132	170
0204	left	42	46	48	48	49	46	*-	42	51
	right	57	55	53	59	57	58	-	57	60
	legs	222	250	260	270	270	190	-	220	330
	back	138	172	150	153	145	100	-	130	172
0205	left	*-	54	52	53	53	54	*-	51	56
	right	-	58	63	60	61	62	-	62	60
	legs	-	290	260	250	260	295	-	260	235
	back	-	145	157	170	160	175	-	160	175
0206	left	*-	40	35	32	34	*-	39	28	26
	right	-	46	49	46	44	-	44	40	37
	legs	-	125	160	130	135	-	130	110	125
	back	-	62	80	84	70	-	80	50	65

*No measurements recorded for these days.

MUSCULAR STRENGTH OF SUBJECTS

		Kilograms of forces			
		First Week	3rd Week	4th Week	6th Week
Gemini	**Group Average**				
	Left hand	48	50	49	50
	Right hand	54	54	55	54
	Legs	226	213	214	244
	Back	132	134	141	144
Formula	**Group Average**				
	Left hand	51	54	51	49*
	Right hand	56	58	57	58
	Legs	170	220	200	209
	Back	126	132	129	131

*This measurement is an average of 5 men only; 0309 omitted.

AMMONIA AND LACTIC ACID LEVELS OF BLOOD BEFORE AND AFTER
STANDARD BICYCLE ERGOMETER TEST
(days 29-31 of study)

		Ammonia, μg/100 ml		Lactic acid, mg/100 ml	
		Before	After	Before	After
Gemini Subjects	0301*	16	238	13.8	74.8
	0303	59	119	5.8	41.3
	0304	-	86	6.9	31.3
	0305	36	56	10.1	24.0
	0308	66	170	29.7	65.8
	0312*	4	94	9.9	54.2
Formula Subjects	0302	68	157	5.4	42.6
	0306	22	138	6.0	56.8
	0307	27	248	15.9	87.7
	0309	10	179	5.6	56.8
	0310	50	235	3.6	75.7
	0311	26	308	5.8	64.5

*S failed to complete ergometer test.

L. Physio-Psychological Fitness

As tests of physio-psychological fitness, complex-reaction time, arithmetic and learning skills, measurements of visual function (primarily that of critical frequency of fusion of flicker, dark adaptation time, and recovery from bleaching on exposure to high intensity monochromatic light) were carried out.

There were no consistent changes noted as a result of the protein manipulation in measured characteristics of visual and neuro processes. Complex-reaction time seemed to improve with experience, but seemed to bear no relation to dietary change.

In the studies of recovery from bleaching on exposure to high-intensity monochromatic light, subjects 0203 and 0205 showed differences, compared with their control periods, after recovery from the 3 g nitrogen intake; however, since these changes were in the opposite direction in each of the subjects and because of the wide variations noted in the controls, those alterations are of no consequence.

In Study #3 an initial difference between the Gemini and the formula group with respect to bleaching and response to monochromatic light was noted, and this was maintained throughout the Study.

The results of these tests are shown in Tables 81 through 84.

Table 81

COMPLEX REACTION TIME, ARITHMETIC SKILLS, AND VERBAL LEARNING
(12 g Nitrogen unless noted)

	0201	0202	0203	0204	0205	0206
I. COMPLEX REACTION TIME						
Day 65	4.13	4.39	4.71*	4.12**	5.92*	4.35*
80	3.80	4.35	3.96	5.19	5.80	4.32
II. ARITHMETIC, CORRECT PROBLEMS/MIN.						
Day 3	4.6	3.3	2.9	2.1	4.4	3.1
10	4.8	3.6	3.6	4.0	4.3	3.4
24	5.3	4.1	2.9**	4.5*	3.3**	3.5**
45	4.7	3.2	4.1*	4.4	4.0*	4.0
59	5.2	3.8	3.6*	4.2**	4.0*	3.4*
74	5.4	4.7	3.9	4.7	3.5	4.9
III. VERBAL LEARNING, WORDS RECALLED/SENTENCE Changes day 70 - day 85						
Degree of Word Embedding						
1	+1	--	0	+7	0	+5
2	+7	+1	---	+20	---	+1
3	0	+2	+2	---	-4	---
Random	---	-6	+7	+7	+8	-6
Mean Change	+2.7	-1.0	+3.0*	+11.3**	+1.3*	0.0*

MEAN IMPROVEMENT (Recall/Sentences)

Controls	3 g	"0" g
0.8 wds	1.5 wds	11.3 wds

*3 g dietary Nitrogen intake
**"0" Nitrogen intake

REACTION TIME, ARITHMETIC AND LEARNING SKILLS

	Day	Gemini	Formula
		Group mean and standard deviation	
Complex reaction time			
	9-11	4.13 ± .77	3.50 ± .21
	25-30	3.93 ± 1.03	3.34 ± .58
	39-40	3.60 ± .80	2.98 ± .23
Arithmetic test, correct problems/min.	5	4.30 ± 2.57	5.58 ± 3.04
	12	4.85 ± 2.57	6.27 ± 3.64
	19	5.20 ± 2.93	6.78 ± 3.59
	26	5.53 ± 2.80	6.05 ± 3.62
	33	5.35 ± 3.05	6.80 ± 3.61
	40	5.21 ± 2.14	6.93 ± 3.21
Verbal learning, words recalled/sentence	19	18.60 ± 2.25	19.55 ± 1.63
	40	16.23 ± 4.77	18.05 ± 3.41

Measurements of Visual Function
CRITICAL FREQUENCY OF FUSION OF FLICKER

Control Subjects (N = 2)	Recovery from Low Nitrogen Diet (N = 3)
23.4	23.0

DARK ADAPTATION TIME, MINUTES

Day	Control Subjects 0201	Control Subjects 0202	0203	0204	0205	0206
69-70	29.00	---	23.30*	30.30**	17.00*	34.30*
80	---	---	21.00	---	---	20.15
84-85	20.45	8.15	30.00	---	19.00	---

RECOVERY FROM BLEACHING ON EXPOSURE TO HIGH INTENSITY MONOCHROMATIC LIGHT, SECONDS

Day	Control Subjects 0201	Control Subjects 0202	0203	0204	0205	0206
69-71	46.4	46.3	6.0*	13.3**	13.5*	3.0*
74	17.1	32.8	17.0	15.7	4.1	1.8
77	16.6	21.9	15.8	14.4	3.8	---

*Recovery from 3 g Nitrogen intake
**Recovery from "0" Nitrogen intake

MEASUREMENTS OF VISUAL FUNCTION

	Day	Gemini	Formula
Critical frequency of fusion of flicker			
	3 - 8	22.21 ± 0.86*	22.16 ± 0.78
	23 - 24	22.56 ± 0.86	22.85 ± 0.45
	40 - 44	22.46 ± 0.90	22.22 ± 0.71
Recovery from bleaching on exposure to high intensity monochromatic light, sec.			
	10 - 11	19.92 ± 15.55	14.05 ± 8.46
	25 - 29	22.61 ± 15.14	10.51 ± 3.19
	39 - 40	21.29 ± 14.11	9.15 ± 3.12
Dark adaptation time, min.			
	3 - 8	11.04	13.03
	40 - 44	11.15 (2)**	10.87 (3)**

*Mean and standard deviation, N=6.

**The number in parenthesis is the number of valid observations included in the mean at this test interval; all other subjects were erroneously recorded as > 20 min.

M. Socio-Psychological Findings

Most of the material in this section is adapted or taken verbatim from the report of Martin Stow. Mr. Stow was a participant-observer in Study #3 and aided in the psycho-social evaluation of Study #2. A more complete handling of this material is contained in "The Legal Structure of a Confined Microsociety," Chapter VI entitled "The Sociological and Psychological Structure of a Confined Microsociety" (Reference 3).

The original purpose of these studies was to examine the effects of nutritional variants on psychological or sociological factors. However, rather early in the studies it became apparent that much of the interaction was so complex and the number of subjects in observation periods so small that it would be quite unlikely that differences attributable to nutritional variables could be determined unless they were very significant and striking. Since the introduced variables were to be only nutritional, no attempt was made to manipulate psychological or sociological factors. Rather, the characteristics of a defined microsociety in terms of socio-psychological patterns were studied as such. These patterns are both individual and group indications of personality and behavior. This experiment afforded an opportunity to compare various psychometric and sociometric tests administered to a single sample population. The population is in no way assumed to be a random sampling of either a general population or a student population, and conclusions must be only tentative because of the small number of subjects.

The following material is a discussion of: 1) subject selection, including the psychological patterns as determined by the Minnesota Multiphasic Personality Inventory and the Food Frequency Questionnaire (Appendixes III and IV); 2) a longitudinal study of group activity which delineates forms of active and passive behavior; 3) a comparison of individual activity behavior with sociometric rankings and personality patterns. One of the practical questions to which this research addresses itself is: if on the basis of psychometric data a group of men is selected to participate in an experiment or situation of social isolation, which defined personality traits should be considered as a basis for selection? An approach to this question in these Penthouse experiments is through the application of sociometric techniques. A working hypothesis was formulated stating that there are psychological characteristics which are associated with group members who are seen as positively affiliated with the group and, conversely, patterns for those who are viewed negatively; and that there is a significant difference between the positive and negative patterns or, failing this, certain discriminating trends.

In Study #2 two types of sociometric data were collected. The first type was a log or journal of empirical observations made upon a fairly constant basis by Donald A. Strickland; this data has been incorporated into the complete report (Reference 3) and will not be discussed here. The second type of data was obtained through the use of an Inter-Group Relational Inventory (IGRI), a common type of sociometric instrument. The information from this instrument was not subjected to statistical examination at a sophisticated level because it was recognized that the size of the experimental group (six subjects) was too limited to permit the projected application of findings with any degree of reliability. However, it is believed that the information derived from these inventories has value for the purpose of further research and therefore it is reported. The IGRI was administered to the subjects of Study #2 six times, approximately once every 2 weeks. This permitted a longitudinal analysis of changes in inter-group relations.

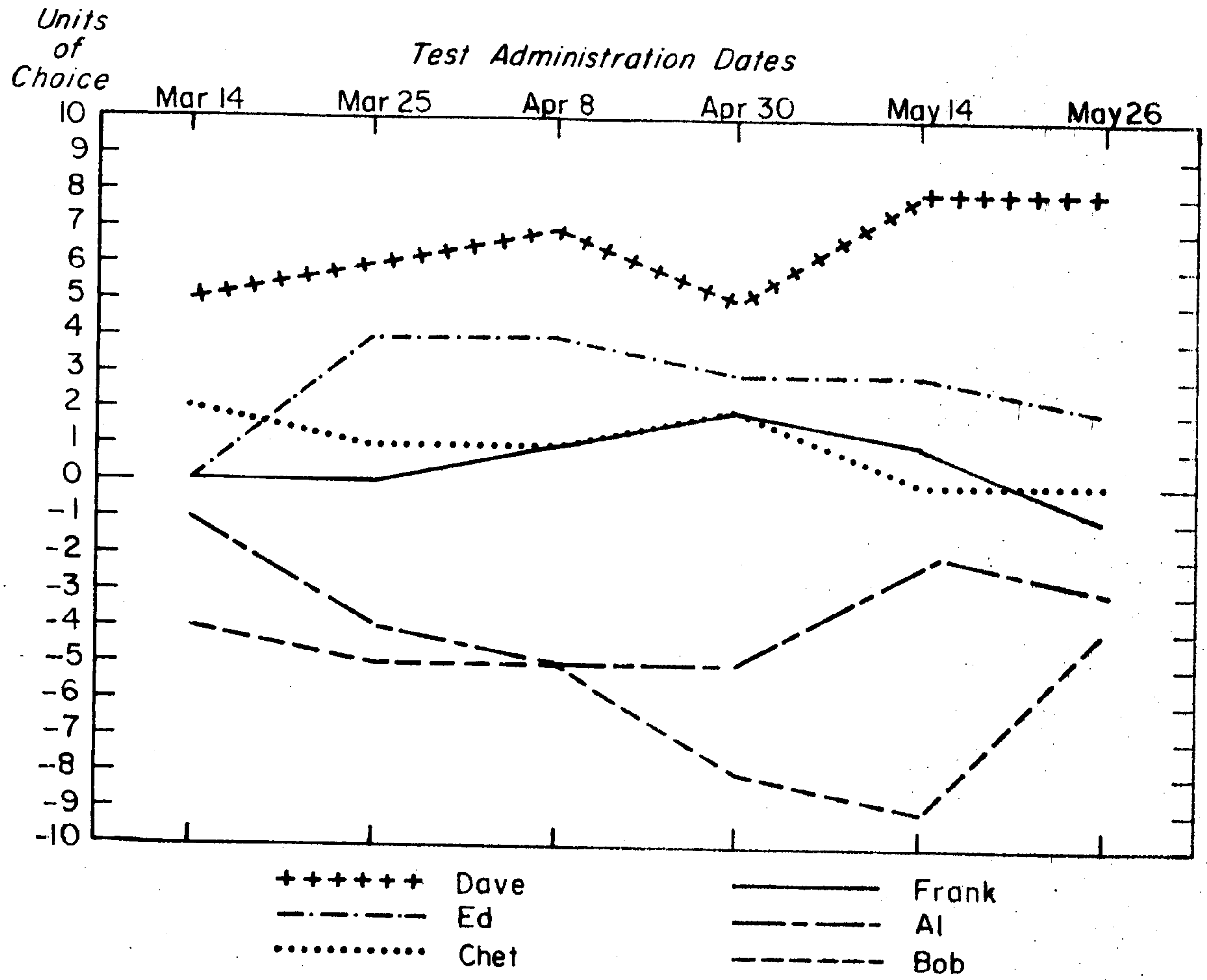
In Figure 15 are shown the scores and rank orders of the subjects of Study #2 longitudinally on a biweekly basis and a graph indicating rejection of choice (i.e., refusal to reveal feelings about group relations at the moment). The rank placements are determined by adjusting the scores for an individual on the collective indices of (a) similarity, (b) friend-under-stress, and (c) work-partner. These 3 indices are weighted equally as positive social characteristics. Figure 16 is a diagram of a sociometric pattern for one biweekly inventory during the study. The columns beneath the pattern indicate the number of positive associations for each subject (the ranking, on the basis of the number of times chosen, of who was most-to-least selected for each index) and the ranking of those least desired. The adjusted ranking is derived by combining the 2 columns and averaging those individuals' scores which are both negative and positive. The units of the ranking are simply the number of individual choices. No attempt is made to determine the qualitative or quantitative aspects of the choice.

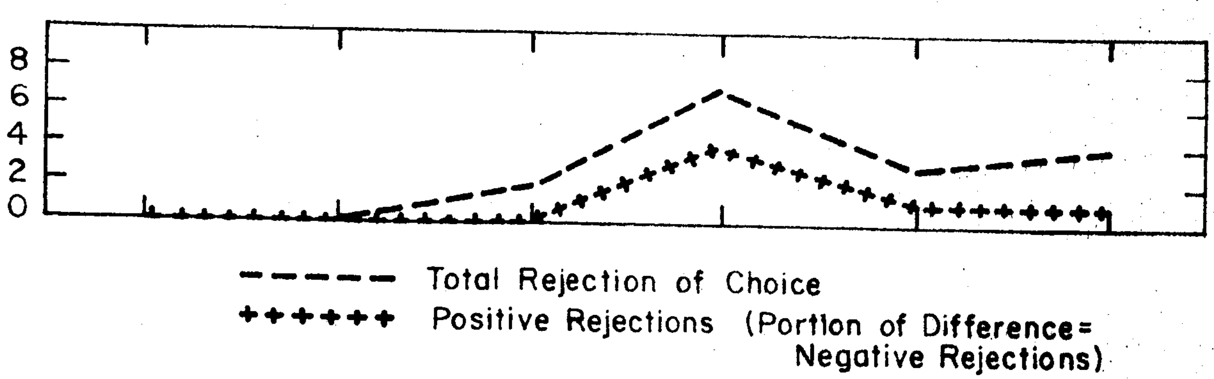
It is apparent that the rankings have remained fairly constant for the duration of the study. A compilation of all inventory data indicates an overall ranking as follows:

Subject:	0201	0202	0203	0204	0205	0206
According to Adjusted Average of Total Number of Units:	6.5	1.0	-5.8	2.7	.5	-3.3

Fig. 15

Penthouse II. Composite Socio-metric Ranking According to Inter-Group Relations Inventory

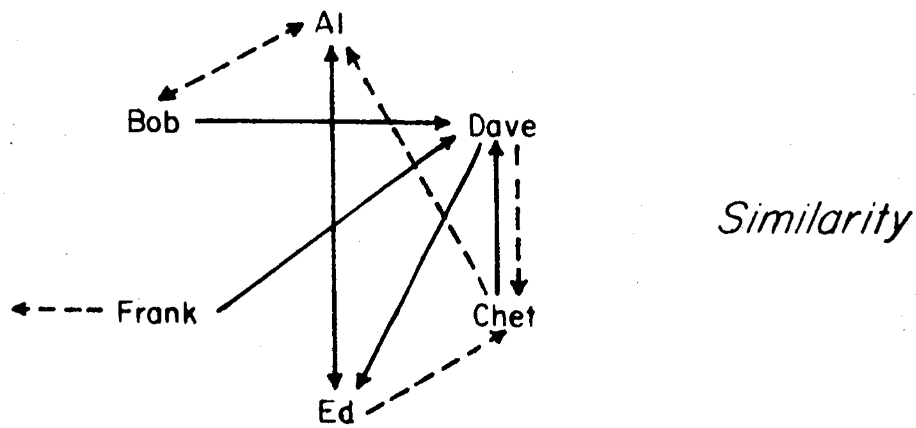


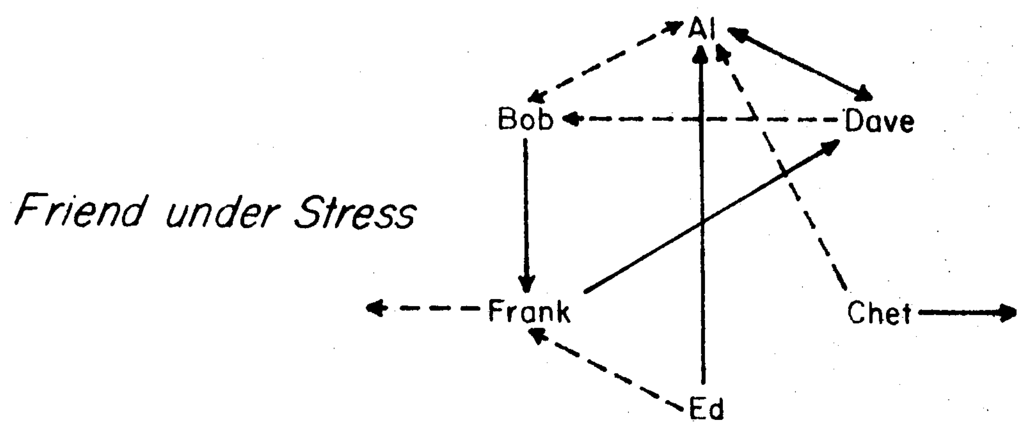


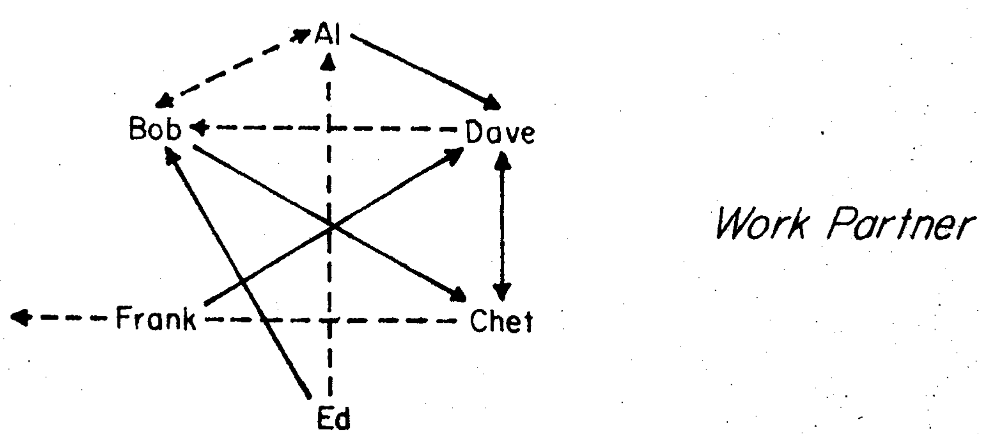
Dave	-	0201	Ed	-	0204
Chet	-	0202	Frank	-	0205
Bob	-	0203	Al	-	0206

Fig. 16

Penthouse II. May 26 Socio-grams for Three Factors (The composite rating is comprised of these three factors)







		Pos. Choices	Neg. Choices	Number Rejected Choices	Adjusted Ranking	
0206	Al	3	6	—	Dave	+8
0201	Dave	8	0	—	Ed	+2
0202	Chet	2	2	1	Chet	0
0204	Ed	2	0	—	Frank	−1
0205	Frank	1	2	3	Al	−3
0203	Bob	1	5	—	Bob	−4

In accordance with our initial question we would be interested in establishing whether or not a particular psychometric pattern exists which would separate the subjects by a specified group, perhaps either the top half from the lower half, or the positive subjects from the negative. Although these experiments lack a control group with which to make comparisons, it is possible to compare the inventory profiles with general norms and to make comparisons between groups of experimental subjects.

Among the tests administered to the subjects of Penthouse Study #2 were the Minnesota Multiphasic Personality Inventory (MMPI), the California Personality Inventory (CPI), and the Adjective Check List (ACL). Profiles for these are shown in Figures 17, 18, and 19. Of the 6 subjects, 4 scored positively and 2 scored negatively; few significant variances among the scores for these groups are to be noted.

The MMPI profile of Study #2 is characterized by its similarity to a college male norm with the slight elevations among some of the factors. Figure 20 shows (a) this profile for Penthouse Study #2 in comparison with (b) an average group score for 30 applicants for Study #3 and (c) an average group score for 11 of the applicants chosen as subjects for Study #3. The close resemblance between the scores of subjects in Study #2 and applicants and subjects for Study #3 should be noted. There appears to be an affinity of MMPI personality patterns among those who apply for this type of experiment. Evaluations of individual personality patterns for subjects in Study #3 are given in Appendix II.

Data from Study #2 would seem to indicate that on the basis of sociometric evaluations by experiment subjects it is not possible to extract distinct personality patterns or significant factor variations if total mean scores for those evaluated as positive are compared with those for subjects evaluated as negative. Utilizing the scores of all subjects "washes out" pattern distinction. One alternative is to select extremes and to make comparisons utilizing these scores.

The scores on the MMPI for the two extreme ranked subjects (those evaluated as highest and lowest on rankings related to similarity and affiliation) are compared in Figure 21. The group mean is also indicated. Some differences are indicated among the factors between the 2 subjects, particularly in the scores associated with neurosis and psychopathic deviancy. Applying this technique to the CPI also produced indications of factor trends for negatives and positives shown in Figure 22.

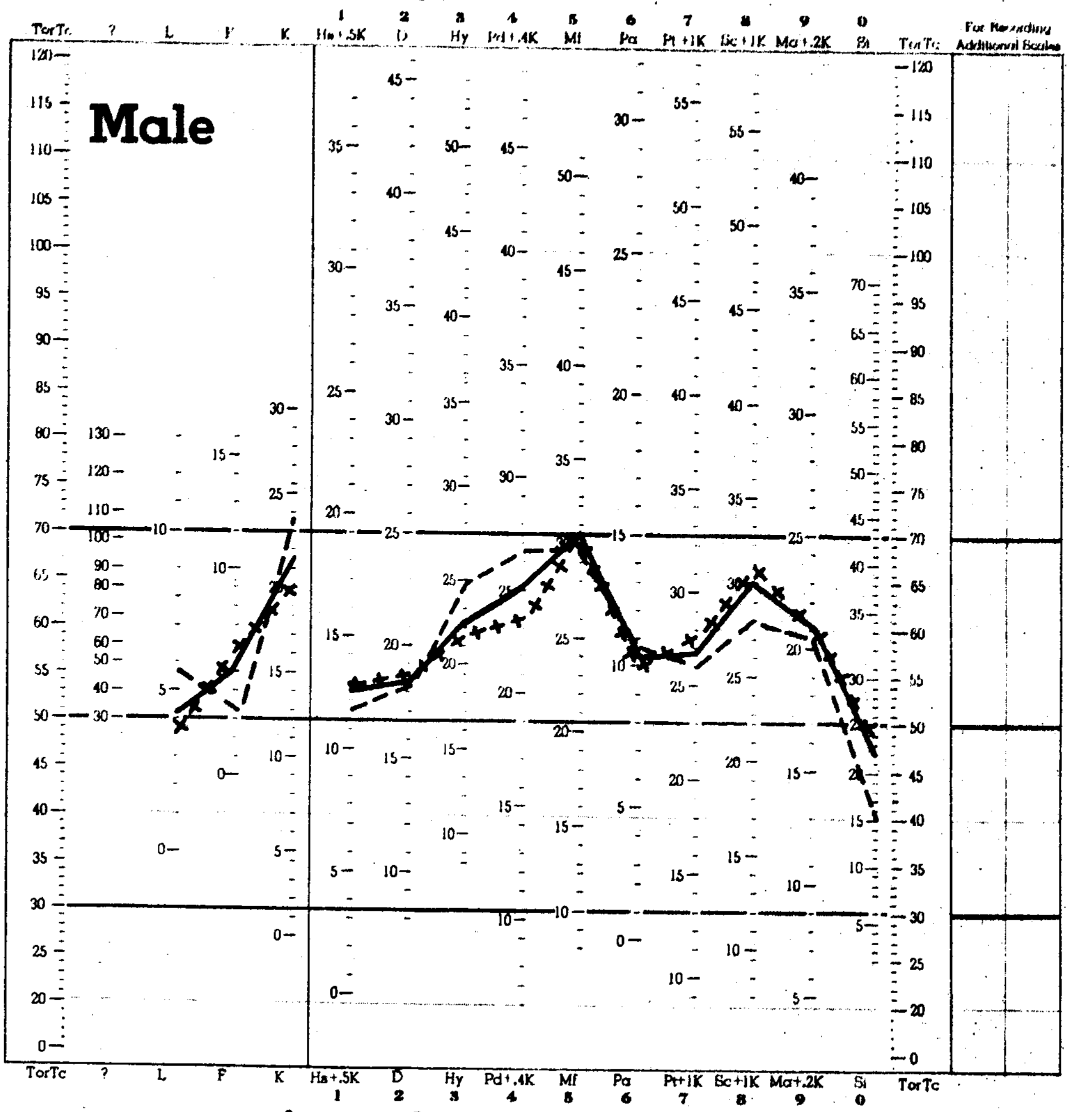
It was decided to apply this type of analysis to the data from Study #3 to ascertain if the increased size of the sample would affect the results in the same

Fig. 17

The Minnesota Multiphasic Personality Inventory

Starke R. Hathaway and J. Charnley McKinley

Penthouse II. Collective Group Scores for MMPI Administered First Week



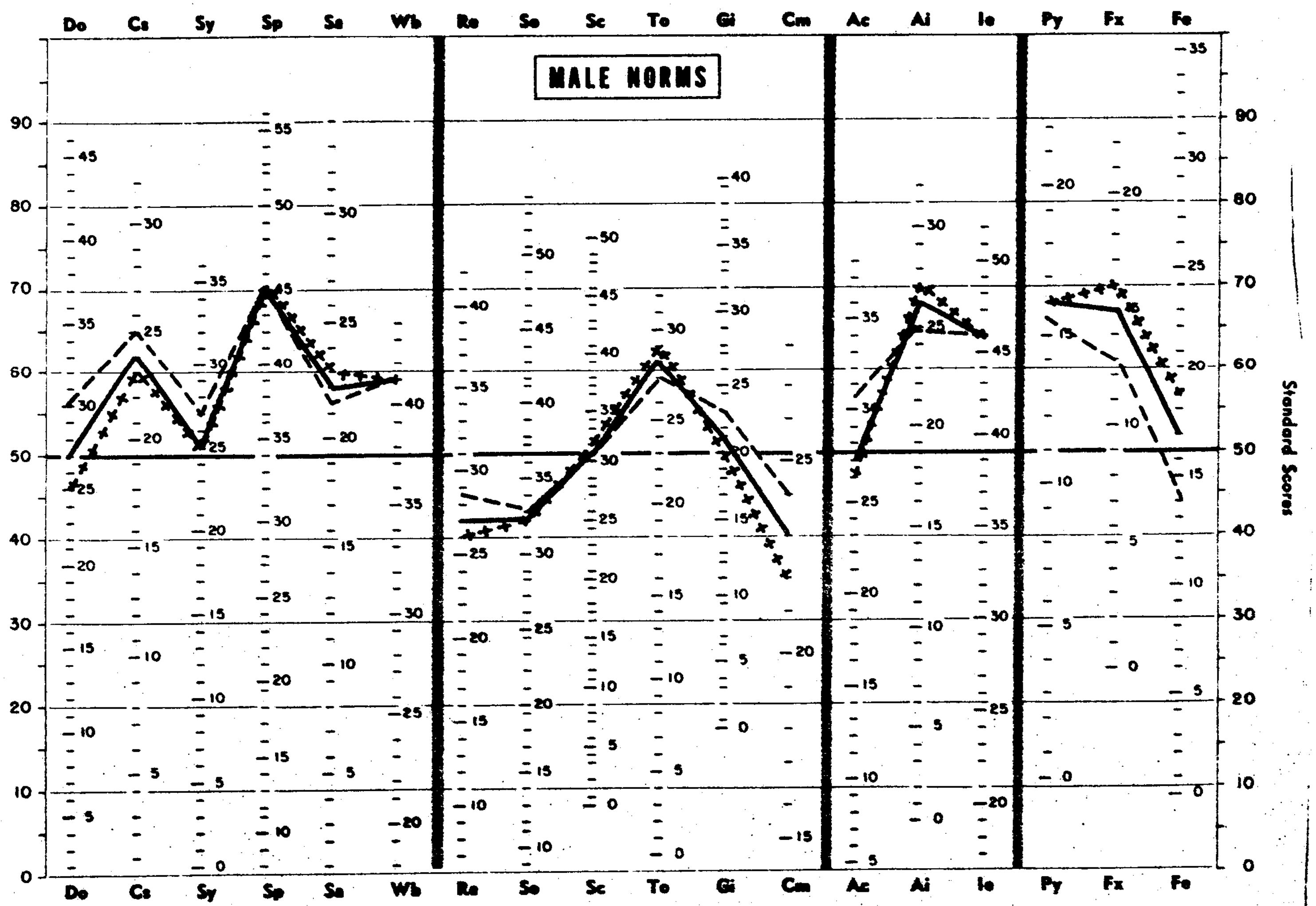
—— Average Scores for Six Subjects

++++ Average Scores for Socio-metric Positives (4)

– – – – Average Scores for Socio-metric Negatives (2)

Fig. 18 *California Psychological Inventory*: **MALE**

Penthouse II. Collective Group Scores for CPI Administered First Week



Average Score for Six Subjects

+ + + + Average Score for Socio-metric Positives (4)

– – – – Average Score for Socio-metric Negatives (2)

Fig. 19 **ADJECTIVE CHECK LIST**

Penthouse II. Experiment No. 2, Collective Group Scores for ACL Administered First Week

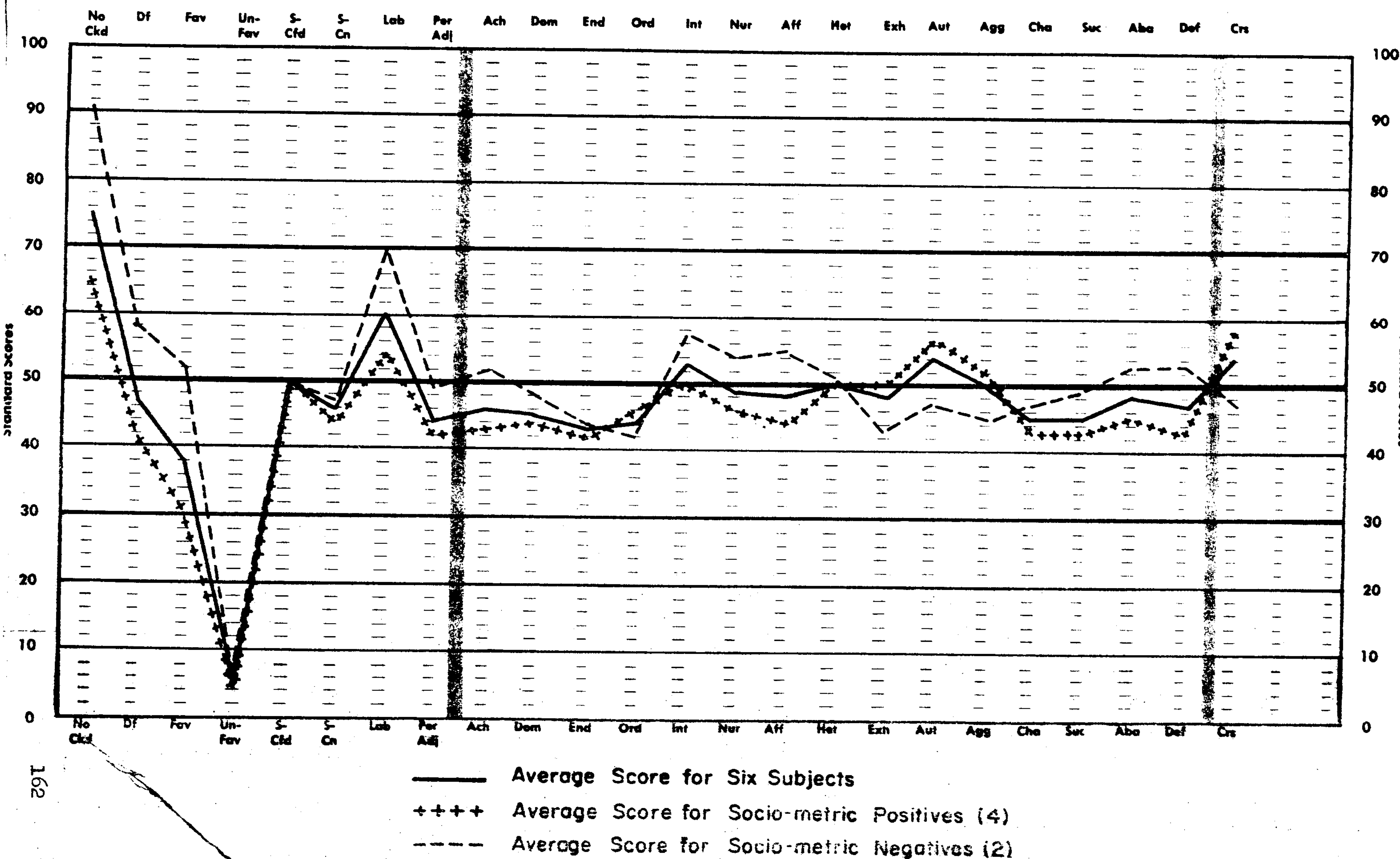
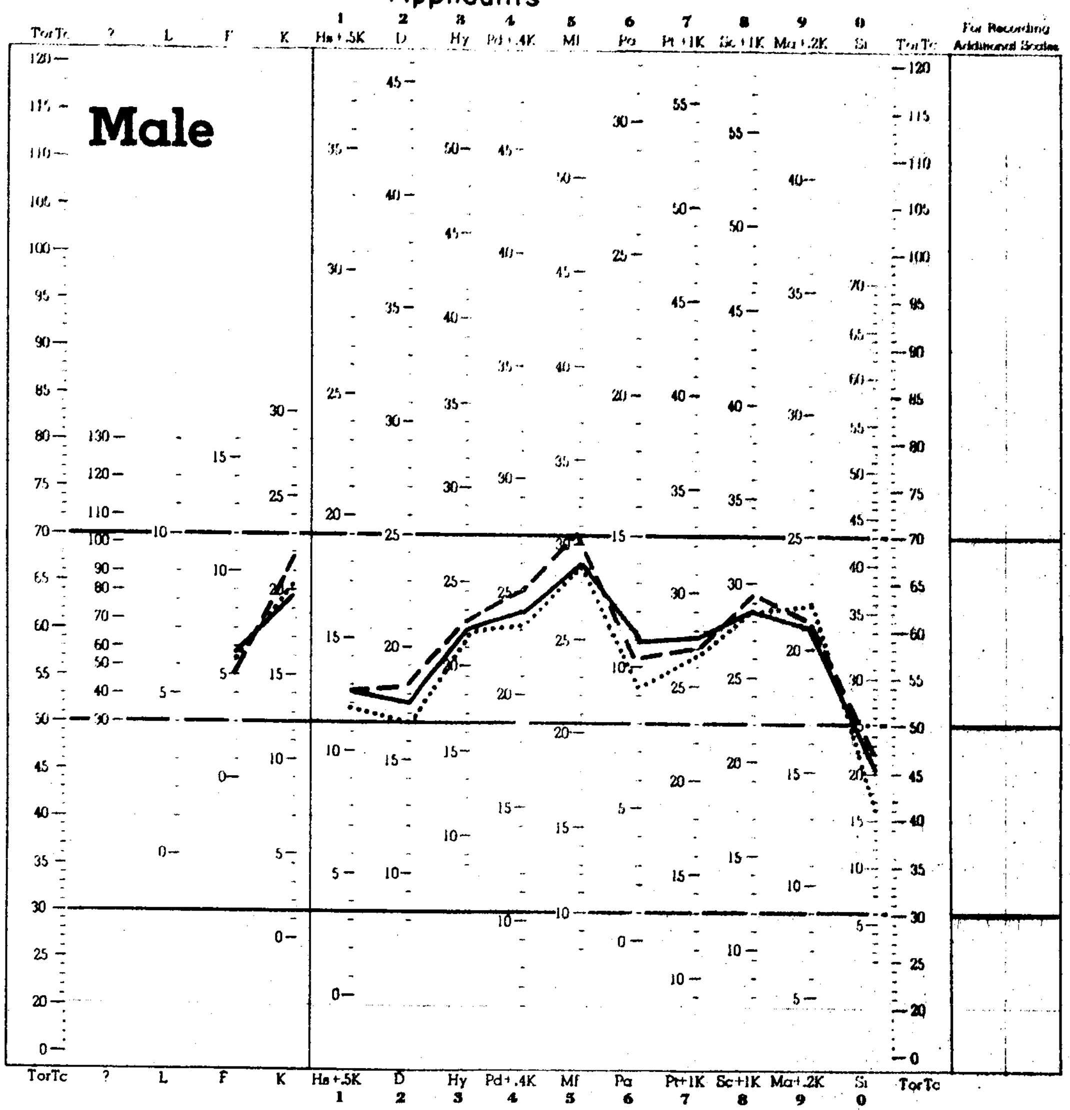


Fig. 20

The Minnesota Multiphasic Personality Inventory

Starke R. Hathaway and J. Charnley McKinley

Penthouse II and III. Collective Scores on MMPI-Subjects and Applicants

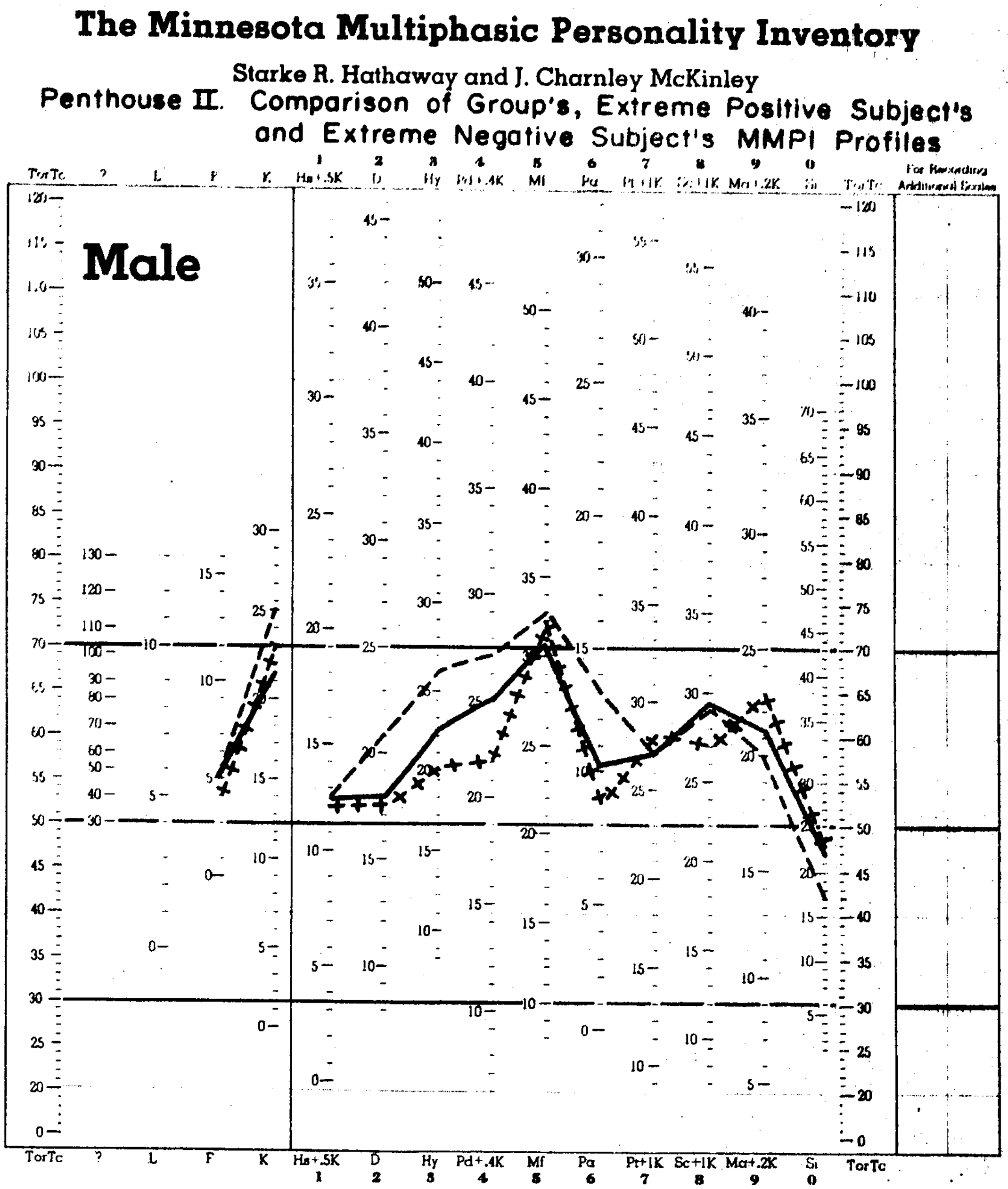


- - - - Penthouse II Subjects

—— Penthouse III Applicants

·········· Penthouse III Subjects

Fig. 21



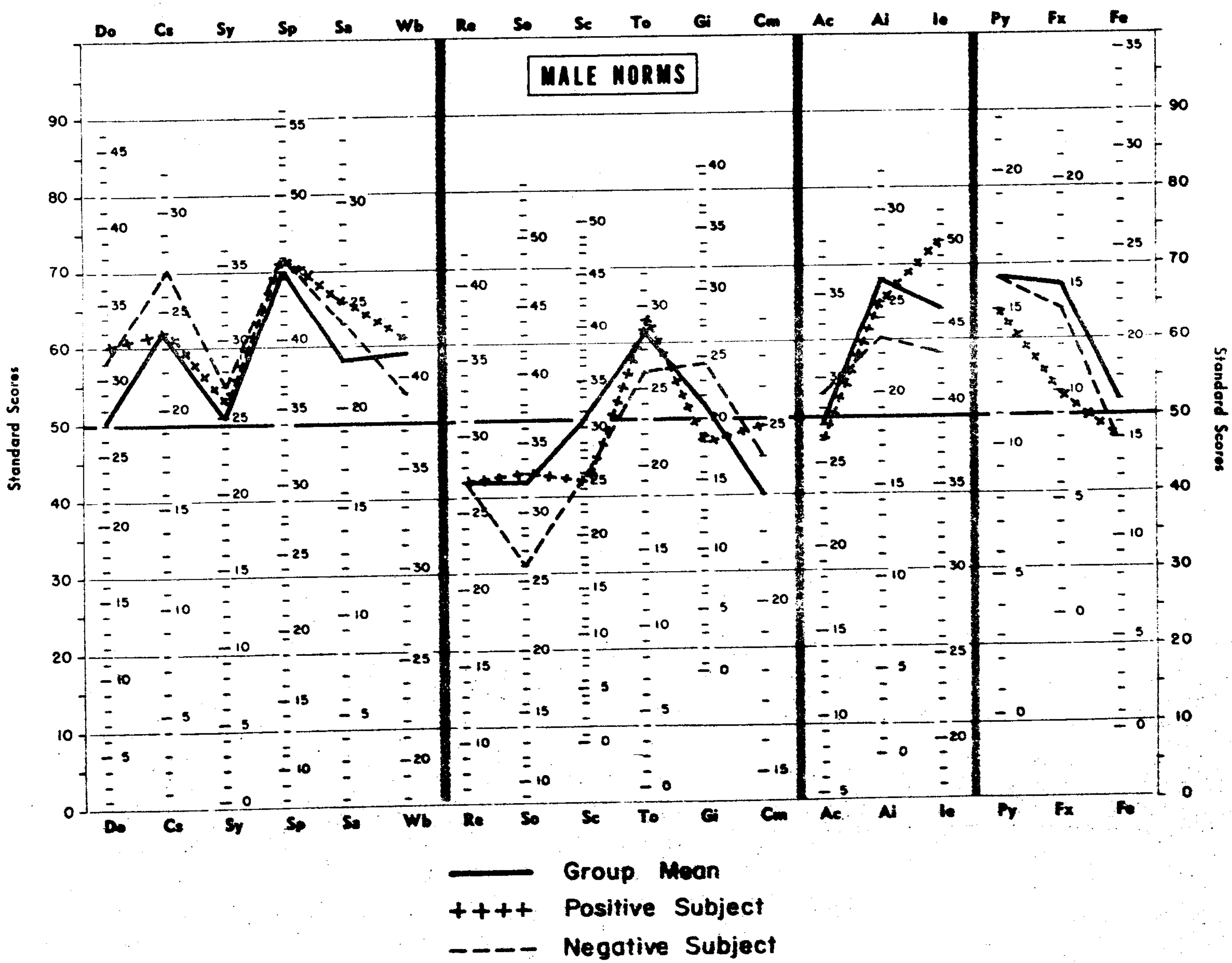
———— Group Mean

++++ Positive Subject

– – – – Negative Subject

Fig. 22 *California Psychological Inventory*: **MALE**

Penthouse II. Comparison of Group's, Extreme Positive Subject's and Extreme Negative Subject's CPI Profiles



direction as that indicated by Study #2. As there were 12 subjects in this experiment, the extreme groups for comparison were doubled to 2 subjects each. Selection of these groups was based upon composite ranking composed of identity and compatibility evaluations made in the last week of the experiment. It was assumed that this allowed the maximum degree of intrasubject familiarity upon which to base evaluations.

In Figures 23-26 are shown positive (accepted, liked) and negative (rejected, disliked) sociometric indices applied to the MMPI, CPI, ACL, and Omnibus Personality Inventory (OPI) for subjects in Study #3. The difference between the scores for the positive and negative subjects varies among the factors in the separate instruments.

Factors with scores differentiated by one standard deviation or more (raw scores on all profiles have been converted to standard scores which permits comparisons among the profile factors) can be tentatively designated as significant. On the MMPI this includes the F, Pd, Sc, and Ma factors which indicate, for example, the negative subjects' significant endorsement of items dealing with "peculiar thoughts and beliefs... disregard for social customs and mores... bizarre or unusual thoughts or behavior" and an indication of "over-activity, emotional excitement, and flight of ideas."* Differentiation in the CPI is found in those measures associated with Social Control (Sc) and, in clusters with less significant differentiation than one standard deviation, Achievement Potential and Intellectual Efficiency. The ACL indicates several factors that have one standard deviation between the closest positive and negative scores. The positive subjects score higher on the use of Favorable Adjectives In Describing Themselves, Intraception, and Nurturance. There is a considerable though not significant difference on Autonomy and Aggression, with the negative subjects scoring higher. A comparison of the average negative scores with the positive scores emphasizes these differences in addition to significant differences within the factors of Self-Control, Personal Adjustment, Endurance, and Succorance. Lastly, the OPI factors which differentiate significantly are those of Impulse Expression, Schizoid Functioning, Response Bias (which has been shown in many situations to measure manifest self-esteem), and less than significant but positively and negatively clustered, Complexity and Lack of Anxiety.

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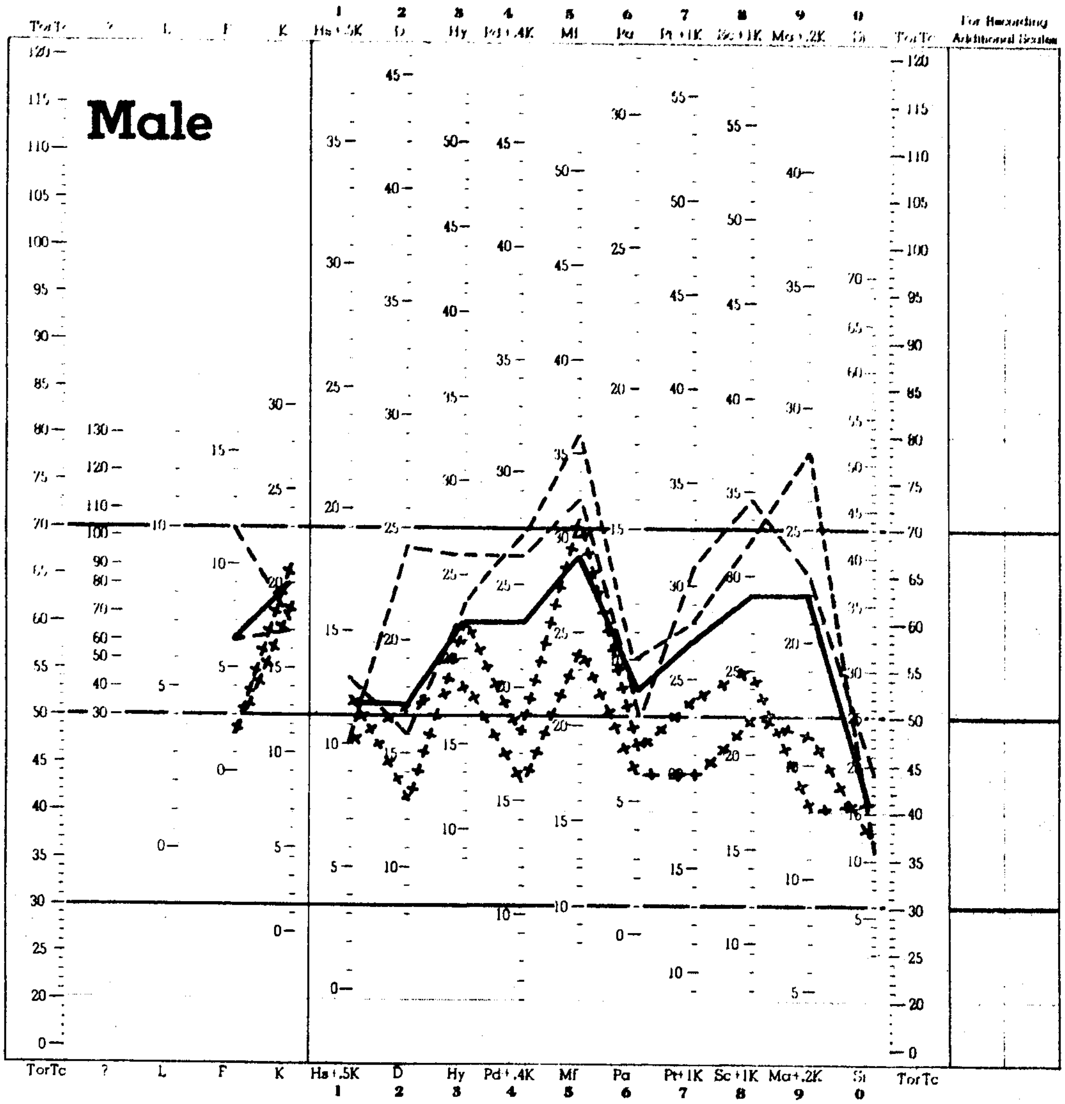
*Interpretive data for these factors found in their respective manuals are abstracted in Appendix III.

Fig. 23

The Minnesota Multiphasic Personality Inventory

Penthouse III. Comparison of Groups, Extreme Two Positive Subjects' and Extreme Two Negative Subjects' MMPI Profiles



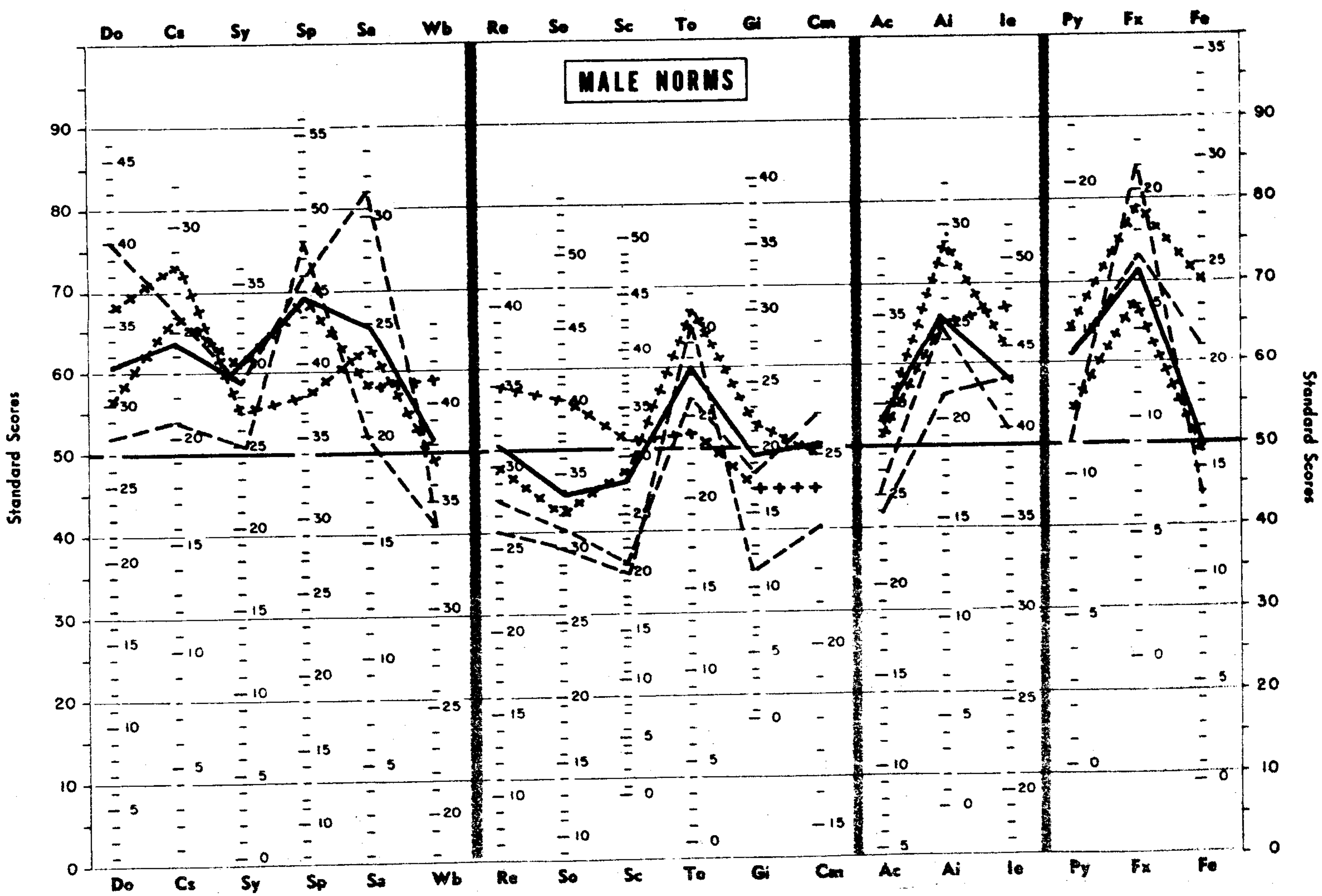
———— Group Average

++++ Positive Subjects

- - - - Negative Subjects

Fig. 24 *California Psychological Inventory*: **MALE**

Penthouse III. Comparison of Groups, Extreme Two Positive Subjects' and Extreme Two Negative Subjects' CPI Profiles



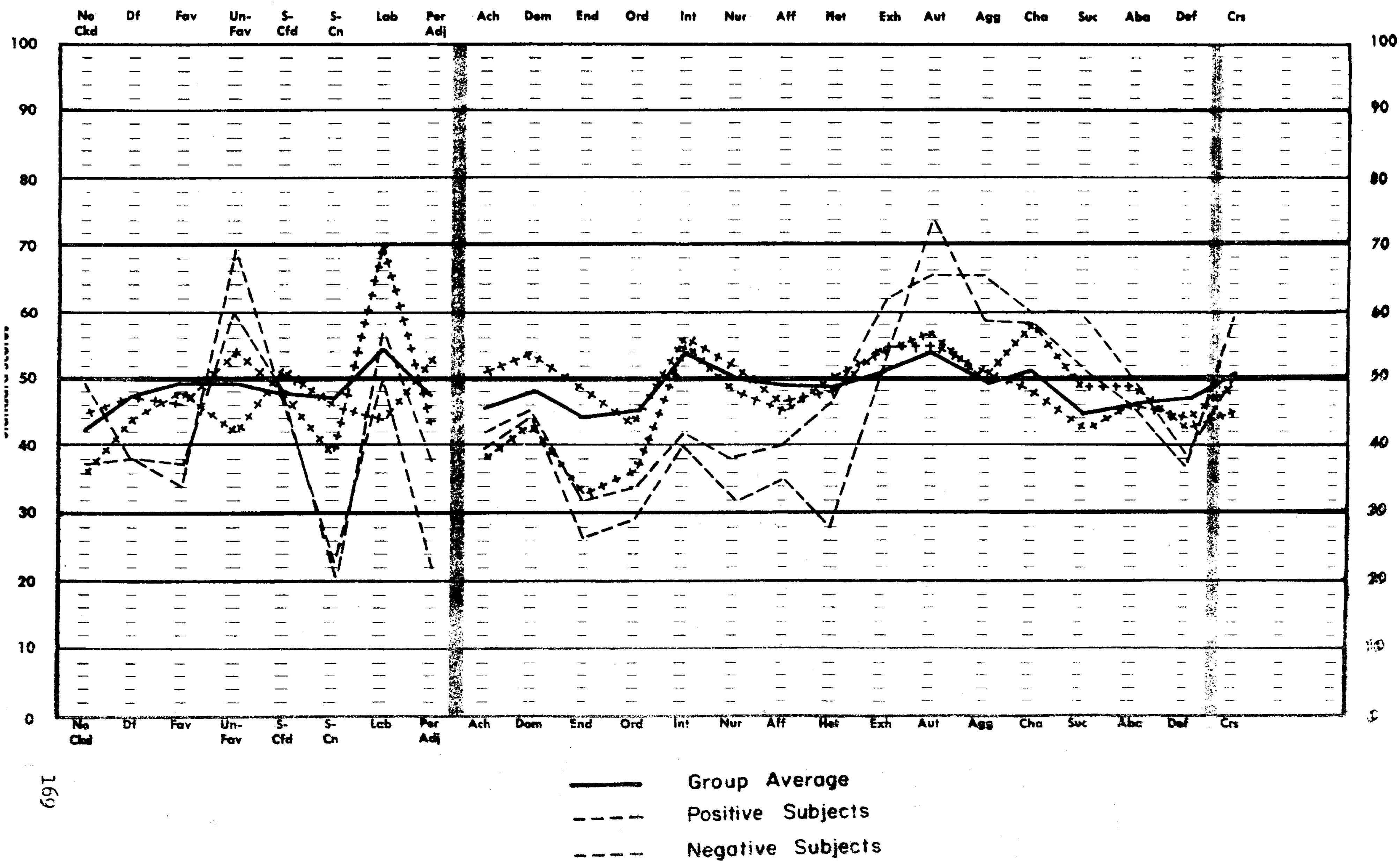
—— Group Average

++++ Positive Subjects

– – – – Negative Subjects

Fig. 25 **ADJECTIVE CHECK LIST**

Penthouse III. Comparison of Groups, Extreme Two Positive Subjects' and Extreme Two Negative Subjects' ACL Profile



OMNIBUS PERSONALITY INVENTORY

Penthouse III. Comparison of Groups, Extreme Two Positive Subjects' and Extreme Two Negative Subjects' OPI Profiles

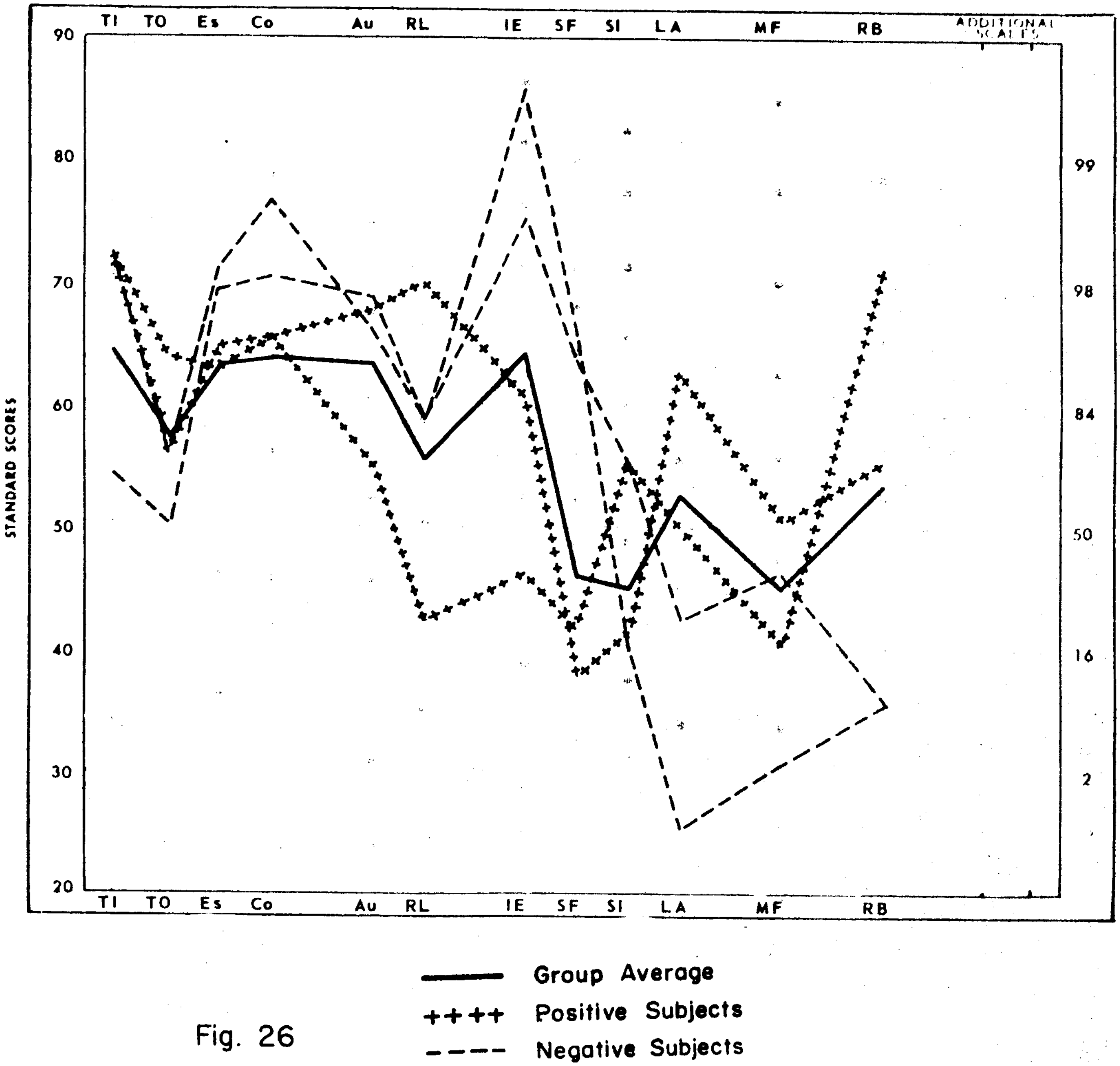


Fig. 26

It is possible that in the selection process other factors would be significant for including or excluding a specific individual. For example, a high Depression score on the MMPI would not be desirable, although this factor does not show up as differentiating positives from negatives. Or, if selection is to be based on qualities other than affiliative compatibility (such as leadership) it might be necessary to accept, for instance, those who score high on the OPI Autonomy and Impulse Expression scales, scales which in this study have been shown to be nondifferentiating and negatively differentiating, respectively.

In Study #3 a self-evaluation of the applicants to tolerate repetitive intake of food was given and an attempt made to use this as a factor in the selection of subjects. Although the self-evaluation of ability to tolerate repetitive menus of Gemini and formula type was only one factor in selection and the information was available to only one investigator among the selecting group, this evaluation clearly differentiated the selected from the population of applicants. As shown in Table 85 tolerance of subjects for repetitive consumption of all but one of 50 designated items (hot coffee being the exception) was higher than that of applicants eliminated for all causes, including those who were acceptable but who obtained other employment. Selected subjects were willing to eat 65 percent of the foods listed as frequently or more than once a day as compared with 34 percent for the other applicants (Table 86). The subject substituted on an emergency basis did not fit the pattern of the preferred subjects but was accepted because he stated that he could eat formula-type food three times a day and had done so. He was assigned to the formula diet and completed the study, but with greater difficulty than most of the others of his group.

It is clearly possible to separate from a larger population a group of men who believe themselves able to tolerate a monotonous diet, or who do not perceive repetitive consumption as monotonous or important. Whether this simple instrument reliably predicts ability to do so is not yet proved. Further, it is our impression that among selected subjects those who indicated the least concern with menu variety were best able to tolerate the entire experimental regimen. If this were true, such an instrument would be extremely valuable both as a selection tool and as a means of studying correlated personality attributes.

As a longitudinal measurement of group activity, a random sampling of the activity of each subject was recorded daily. The day (from 8 a.m. until 11 p.m.) was divided into 15-minute periods. These periods were numbered consecutively and a random selection of 10 periods were chosen daily using a list of random numbers. At these specified times, a survey was made throughout the experimental area to

ACCEPTABLE FREQUENCY OF EATING SELECTED FOOD ITEMS

	Frequency, times per week		
	Selected Subjects*	Substitute Subject	Other Applicants
Fresh whole milk	20.2	14.0	15.0
Hot coffee	13.7	21.0	14.2
Buttered toast	15.6	2.0	9.5
Tea with sugar	11.0	21.0	8.6
Grape juice	13.2	0.5	7.4
Grapefruit juice	11.9	1.0	6.5
Plain chocolate bar	13.4	1.0	6.4
Orange-grapefruit juice	12.8	1.0	6.2
Iced coffee	7.6	0	6.0
Bacon	10.3	1.0	5.8
Cocoa	11.7	1.0	5.5
Mashed potatoes	9.6	2.0	5.3
Applesauce (dup)	9.2	1.0	5.3
Applesauce	9.2	1.0	5.1
Dry raisins	10.3	1.0	5.1
Pineapple juice	8.8	1.0	5.0
Chocolate brownies	10.1	0.5	4.9
Ice cream	9.8	0.5	4.9
Green peas (canned or frozen)	7.4	0.5	4.6
Gingerbread	6.3	0	4.4
Scrambled eggs	7.8	2.0	4.4
Sausage, breakfast type	8.4	0.5	4.4
Dry apricots	7.9	0.5	4.3
Cheese w/crackers	10.3	1.0	4.1
Chicken w/gravy	6.2	0.5	4.1
Cinnamon toast	6.8	0	4.0
"Metrecal"	7.7	21.0	4.0
Chicken w/vegetables	6.8	0.5	3.9
Potato salad	6.2	0.5	3.9
Shrimp cocktail	7.1	0	3.8
Corn, canned, whole kernel	9.6	0.5	3.7
Sugar-coated corn flakes	6.7	0.5	3.4
Chocolate pudding	8.2	0.5	3.4
Malted milk shake	9.0	1.0	3.3
Peanut butter w/crackers	5.0	0.5	3.3
Beef w/vegetables (stew)	7.9	0.5	2.9
Tuna fish salad	5.0	0.5	2.8
Mashed squash	4.9	0.5	2.7
Dry peaches	9.0	0.5	2.7
Salmon salad	6.6	0	2.7
Spaghetti w/meat sauce	6.1	0.5	2.5
Beef jerky	9.2	0.5	2.5
Egg nog	7.8	0.5	2.4
Potato soup	4.7	0.5	2.1
Butterscotch pudding	3.8	0.5	2.1
Apricot pudding	5.2	1.0	2.0
Fruitcake	4.6	0.5	2.0
Clam chowder	4.2	0	1.8
Codfish cakes	3.3	0.5	1.7
Crab newburg	4.8	0	1.2
Parsnips	4.2	0.5	0.4

*One subject failed to complete the questionnaire.

PERCENTAGE OF 50 DESIGNATED FOODS ACCEPTABLE AT VARIOUS SERVING FREQUENCIES

Acceptable Frequency	Percentage of items in category			
	All applicants	10 Subjects*	Substitute Subject	Other Applicants
3/day	9	16	6	5
2/day	12	17	2	10
1/day	24	33	2	19
2/week	28	20	12	33
1/week	14	9	28	18
1/2 weeks	7	2	30	8
Rarely or never	6	3	20	8

*One subject failed to complete the questionnaire.

determine each individual's activity. Activity was categorized as follows:

Grouped		Isolated			
Active	Passive	Active	Passive	Staff - Phone	Duty
Conversation Cards	Reading with others TV (if with others in room) Hi-Fi	Reading alone Writing Hobbies Drums	Sunbathing Sleeping Withdrawn	(Conversation with staff members; telephoning outside)	Eating Toilet Ergometer All tests Bathing Treadmill Scheduled activity excluding Flatus experiment

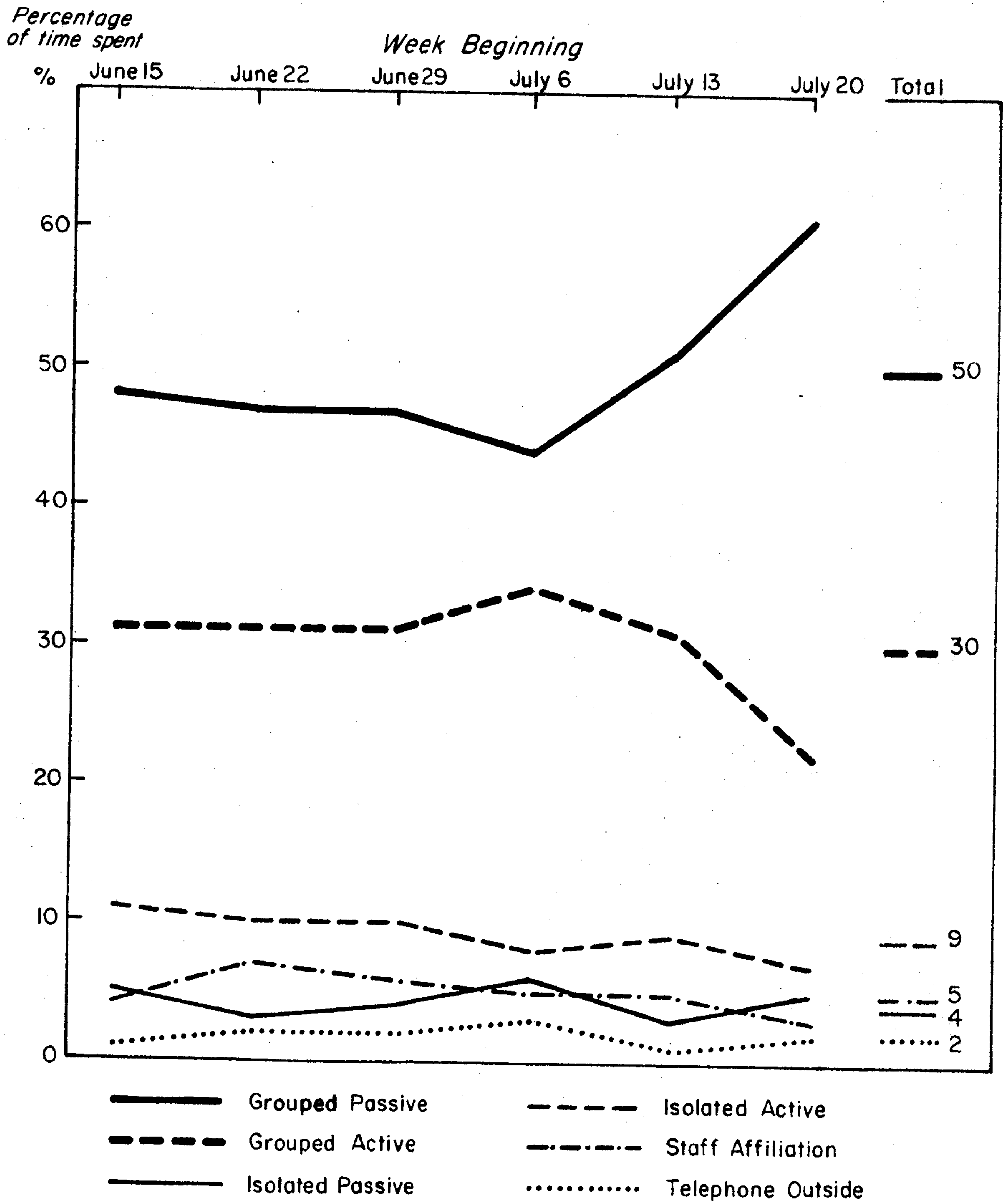
Some activities could be classed as either grouped or isolated and active or passive, depending upon the condition. Reading in a group was classed as passive as it was a form of resistance against group communications; reading alone was isolated active as it appeared to be a resistance against solitary inactivity. The purpose of this inventory was to measure the percentage of time spent in each of these categories, individually and collectively, and the degree of change which might occur during the course of the experiment. In the final results "Duty" was isolated from the remainder of the activities as the individual had no control over this item.

An analysis of the individual subject's data on the Group Activity Inventory does not show a positive correlation between categories of activity for the subjects in general. Individual deviation from the average group score for categories indicates that subjects with the highest socio-positive and socio-negative indices are those who vary greatest from the group means. This would seem to suggest that positive and negative affiliates display behavior which is less predictable based upon group norms.

The collective data for the total experiment group are contained in Figure 27 The information is presented by week for the 6-week period. The percentage is for the week beginning with the date indicated; there were approximately 70 inventories per week. For the initial 3 weeks the activities remained constant with the exception of an increase in staff affiliation during the first week. A slight increase in grouped activity occurs in the third week, accompanied by a slight decrease in isolated activity and grouped passivity. Then in the fourth week while isolated, staff, and telephone activities remain constant, there begins a steady increase in grouped passivity with a concomitant decrease in grouped activity. This continues throughout the remainder of the experiment. As indicated,

Fig. 27

Penthouse III Composite Activity Indices According to the Group Activity Inventory



conversation among subjects and intergroup games are the primary grouped activities. It is in these activities that the decline occurred. It should be noted that whereas the grouped function did not change the form of the grouped activity became more passive in nature. Individual subjects did not attempt to isolate themselves physically, but rather mentally. It is true that the limited space also limited the extent of physical isolation possible; however, this would not account for the specific change in the grouped activity. Furthermore, what isolated passivity there was remained constant rather than increasing at the expense of isolated activity.

If we examine the direction of this variance from the norm, we find that the socio-extremes behave in an opposing manner. Within the category of Grouped Activity, the extremes behave as we might expect on the basis of sociometric evaluations: subject 0310 (positive) indicates the greatest percentage of total time spent in Grouped Activity; subject 0306 (negative) shows the least. This is positively correlated with their affiliational acceptance and rejection. These interpretations hold true also for the categories of Grouped Passive and Isolated Active in the same direction: subject 0306 is highest in Grouped Passive and Isolated Active, while subject 0310 is lowest. The implication is that one necessary quality of positive affiliation is Grouped Activity. This holds true in general for the socio-positives as a group; they were above the group average for Grouped Activity. In this microsociety, subject 0306, the individual who appeared most active in isolation, was most rejected by the group.

To a significant extent the subjects spent the greatest amount of their Grouped Activity time with those whom they viewed as most similar to themselves, and spent the least amount of time with those viewed as least similar. The amount of time spent with an individual is strongly related to a subject's preference for his friendship and, only slightly less, his desirability as a working partner.

To the extent possible, subjects in this type of microsociety attempt to limit and decrease their interaction with those with whom they either do not identify positively or are least compatible. It follows that these latter subjects would be isolated from a substantial degree of Grouped Activity. This is confirmed by comparing the subject evaluative data from the IGRI and the amount of grouped activity interaction for the subjects indicated by the Group Activity Inventory. Generally, those subjects viewed most negatively have the least amount of interaction with other group subjects. As the actual physical space decreases the individual subject is less able to isolate himself from those he views negatively as either dissimilar or not compatible.

It has been stated previously that our experimental groups show a typical, but intensified, college male pattern. This in itself implies certain distinguishing characteristics when compared to the norm for males in the general population. This group has more intellectual ability and motivation: it has greater social presence and aggressiveness. However, this is coupled with an uneasy psychological balance which is impelled toward change. It could be expected that the personality which we have described would not acquiesce to the rules of the experiment without overt or covert opposition or compensating behavior.

Although the group recognized a priority of rule compliance, even those requirements with the highest priority were challenged. Those of low priority were drastically modified or ignored. It might be asked if this was not simply normal resentment of rules of the type displayed in any structured social situation as, for example, the military. Empirical observations as well as psychometric data suggest that not only was the opposition of greater intensity, but it was of a more diverse scope. The personality pattern, too, indicates a wider scope of diversity and suggests psychological deviousness as well.

What is the effect of the control of this antithetic motivation upon the individual experimental subject? Here we must move from a group to an individual consideration, although we have in mind group phenomena. The subject desires to maintain his individuality. Consequently, he has to view himself and be viewed as independent. This is difficult in confinement, which has the effect of intensifying the need for independence. The maintenance of "psychic space" becomes of primary importance.

A measurement of "psychic space" is not easy to obtain. In this experimental setting it might be translated physically into time spent in isolated activity or group passivity. Both require an individual defense against, or a reaction formation toward, the demands of the environment. The isolation from external stimuli in both instances is a maintenance of psychic independence. In the grouped situation it is easier to interact than to remain passive; in the isolated condition it is easier to withdraw than to remain active. In the one case, the individual is countering acticipated invasion, while in the other independent activity acts as a defense against possible invasion. During Study #3 approximately 59 percent of the time was spent in these two categories, grouped passive and isolated activity. Considering the space conditions that made physical isolation almost impossible, and a lack of constant inter-personal communications improbable, this is a significant amount of active independence maintenance. It should be noted that in the last half of Study #3 this independence within the group increased considerably.

The maintenance of "psychic space" has been considered here in terms of active withdrawl and primarily as a means of assuring independence. Not even the need for affiliation contradicts this assumption. "Psychic space" has no meaning out of the context of group structure. The subjects of these experiments indicate a high need and ability for social interaction, but it is the increased probability of interaction which allows more independent behavior. There is no gratification in acting independently by one's self: who is there to appreciate the ingenuity displayed in maintaining one's independence?

There is also the state of Passive Isolation. The subjects of Study #3 spent approximately 4 percent of their time in isolated passivity (this excludes the hours of sleep between 11 p.m. and 7 a.m.). The activity designated as "isolated passivity" was primarily sleeping and withdrawl. An average of 36 minutes per day was spent by each subject in absolute psychological isolation, or slightly over 7 hours per day for the group. It is interesting to note that this figure remained relatively constant throughout the duration of the experiment. This withdrawl behavior can be partially explained by reference to the elevated schizoid factor in the inventory data.

The Penthouse Study #3 Inter-Group Relationship Inventory measures 3 influence factors: influence with the project director (an M.D.), with peers (other subjects), and with one's self. The following table compares the degree of Grouped Activity with the ranking of peer influence and personal influence:

Degree of Grouped Activity	Peer Influence	Personal Influence
0310	0311	0311
0305	0312	0310
0302	0306	0304
0304	0310	0312
0307	0302	0302
0309	0309	0307
0301	0304	0306
0312	0305	0305
0311	0307	0303
0308	0303	0309
0303	0301	0308
0306	0308	0301

During the total experimental period, the same subjects are seen as influential (in the highest quartile) with the project director personally; but in the case of peer influence, the subject with the lowest ranking overall evaluation is ranked third in the top quartile by the second and subsequent weeks of the experiment.

In the other 2 influential factors, this subject ranks in the lower quartiles. While there appears to be a positive correlation between types of influence, this relationship is not constant between the level of activity and influence. Factors other than group activity affect subject evaluations of influence.

This suggests that some group opposition is being expressed. Subjects are generally of the opinion that their peers have greater opposition to the established experiment structure than they attribute to themselves. This may be the way in which opposition is "safely" expressed by the individual subject. We might expect that a difference exists between the evaluation of individuals by their fellow subjects and by staff members. It is possible that group opposition to the staff or the experiment might be expressed in terms of rejection of those subjects who are seen as more influential with, or acceptable to, the staff. A comparison of staff and subject evaluations revealed: 1) exact agreement between staff and subjects as to most influential subject; 2) one-ranking difference only between staff and subject evaluation of least influential subject (subject evaluation based upon Personal Influence rating); 3) seven to 10 rankings difference between staff and subject evaluation of least influential subjects, based on subject influence with project director and peer influence, respectively; 4) within the first and fourth quartiles of subject evaluation of Personal Influence generally a significant agreement with the staff. The one exception in the highest quartile is the subject who received the highest overall rating by the subjects.

Any opposition by the subjects is seen as group and not individual opposition. The individual subjects see others as opposing, but not themselves, based on a comparison of Peer and Personal Influence with staff influence ratings.

Among the factors other than influence there is greater divergence between subject and staff evaluations. Here it is necessary to draw rough similarities between subject personality factors ranked by the staff and the subjects' evaluations expressed by the sociometric instruments. By comparing the 2 positive and 2 negative subjects with staff evaluations, we find: 1) the subject evaluated the highest by the group received no top rating by the staff in either positive or negative attributes, although he was viewed quite favorably (second in intelligence, third in maturity, fourth in independence and normalcy of behavior); 2) the subject evaluated the lowest by the group was rated by the staff as the most aggressive and the least influential and mature; 3) the subject second highest in group acceptance was rated by the staff as exhibiting the most normal behavior and the least aggressive and anxious (in an evaluation not reported elsewhere in the study this subject was also rated by the subjects as the most calm); 4) the subject second lowest in acceptance was ranked by the staff as the most anxious and the lowest in normalcy of behavior, independence, and helpfulness.

Generally, we can assume that there is no conflict between staff and subject evaluations. Positive subjects are evaluated as possessing positive characteristics by the staff and negative subjects as manifesting negative behavior. Since the subjects were precisely aware of which subject was most influential with the project director, we can assume that the subjects were generally knowledgeable of staff opinions.

The one area of notable inconsistency between staff and subject evaluation occurs in the individual subject's assumption that his fellows were more willing to be influenced by the subject who was ranked as the least compatible. This may indicate a latent hostility within the group which was overtly displayed during the fourth week of the experiment. At that time, opposition to certain aspects of the experiment was initiated by the subject evaluated as most negative (least compatible) and was expressed in a petition supported by 9 of the 12 subjects.

The decrease in conversational recreational interaction suggests the possibility that the motivations stimulating these activities decreased, although the need for group affiliation remained constant. The stimuli offered by new relationships were exhausted in this experiment of 6-week duration by the end of the third week. The third week ended with a slight increase in grouped activity and then the decrease began, first slowly and then, by the beginning of the fifth week, with acceleration. The latter may be accounted for by the expectation of experiment termination, although the opposite effect (greater grouped activity) seems just as reasonable.

It was during the fourth week that organized opposition to part of the experiment occurred. This would seem to suggest greater conversational activity, but the opposite was the case. This fact, in turn, suggests an anxiety factor. The increase in anxiety as a function of social isolation may be responsible for individual withdrawl within the grouped setting.

In summary, it appears that while grouped and isolated activities remain constant in such a socially isolated group inter-personal grouped activities begin to decrease rapidly after a certain period--in this case, half-way through the experiment. Affiliation needs appear to remain constant, but not active communication needs.

N. Socio-Legal Findings

This investigation was conducted independently and has been reported to the National Aeronautics and Space Administration in full by Drs. Thomas A. Cowan* and Donald A. Strickland** (Reference 3). We abstract here those points salient to appreciation of the milieu in which the physiologic data were gathered.

We use the legal term "findings" instead of attempting to state experimental results. This choice of terminology allows us greater leeway in relying upon subjective factors of experience, intuition, and even surmise, rather than the relatively controlled and objective results that are ordinarily based on scientifically processed data... We therefore have not hesitated in this summary statement of findings to venture conclusions which, in a scientific setting, could only be described as proto-hypotheses, or at best as hypotheses, more or less well formulated...

Our most general conclusion is that in a group confined for purposes of physiological experimentation it is feasible to extend the spectrum of the investigation to include psychological, sociological, political, and legal behavior of the confined group... We learned that subjects must be specifically apprised of the nature and extent of the investigation where psychological-legal work is to be done. It cannot be assumed that a general interest in and willingness to submit to physiological testing can automatically be extended to psychological, sociological, or socio-legal testing. Much of our data indicate quite the contrary...

We suggest that socio-legal investigators take advantage of existing experimental groups instead of trying at first to create their own more tempting groupings. Despite the fact that one can hardly resist the temptation to devise his own experimental settings, our experience indicated that the very great advantages to be derived from studying the relatively real societies of other investigators make the work of the socio-legal investigator much more feasible...

We found that greater resistance exists to political and legal investigation than to psychological and sociometric testing. We allow this finding to stand as a warning without venturing to suggest reasons, obvious or abstruse, for the difference in attitudes...

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We found that our Penthouse II and III groups permitted us to observe the formation of what we have called the "legal structure of a confined micro-society." The groups' major objective--the physiological experiments--gave them a central purpose around which "law-making" could form. Our definition of law as the resolution of conflict by sanctioned rules proved feasible in unearthing legal data. The group possessed sufficient solidarity and enough incentive for conflict-resolution...

We found that our confined micro-societies were reluctant to formulate rules for their own governance. The kind and degree of this resistance is the main burden of our study. At this point we merely summarize it in the form of a general rubric.

We found it necessary to construct a general concept which we have designated "Anti-Law" to contain all the variegated resistances, evasions, slurrings-over, oppositions, and resentments aroused against the legal exactions which existed or arose to constrain these confined micro-societies.

Anti-Law falls into two main subcategories: resistance to explicit agreed-upon rules emanating from external authority (exo-legality); and resistance to the internal inchoate and generally unexpressed but nevertheless quite real patterns of restraint and conformity imposed by the group on its own members. In brief, the society's internal legislation and adjudication (endo-legality).

Dialectic tension between Law and Anti-Law are the warp and woof of our work on the legal structure of these societies.

Without reference to whether the activity could be designated "legal" or not, we found a general inclination on the part of our subjects to single out one after another activity in the micro-society, to characterize it as "inessential" to their overall purpose, and to attempt to jettison it.

We venture no opinion on whether there is a general tendency on the part of confined temporary societies to pass into a state of relative inaction.

We found that in reacting to the constraints of exo-legality, the subjects persistently challenged and otherwise tested all its rules. This activity went on, wittingly or unwittingly, during the entire duration of the experiments. We found even among the more compliant subjects a kind of pressure-equalization effect vis-a-vis the rules. The rules were both (a) resisted and complained against and (b) cited with over-emphatic approval and insisted upon. Such pathogenic legalism we include under the conception "Anti-Law."

Our use of the mental construct or scientific metaphor "Psychic Space" was unremitting. We found that this conception serves to focus much of the observational data of all investigators concerned with this study.

The conception is not primarily legal, but social-psychological. It sums up the individual's effort to maintain independence against group exactions. Its legal incidence is of course obvious for the law knows no sharper conflict than that between individual and group interests. This important area of both law and jurisprudence is not investigated in this report. What does emerge, however, are the manifold ways in which confinement and a common group purpose serve to raise the level of importance to each individual of what seems necessary to do to preserve his individuality against the pressure of group affiliation where almost constant social contact can hardly be avoided.

We found that the subjects staked out areas of exclusive or special use and that they acted hostile in response to "trespasses" into these areas. We found a general tendency to insulate both affectional and aggressive feelings from the effects of crowding... By use of the term "psychic space" we have in mind the congeries of all efforts to preserve psychic distance, all behavior designed to keep others from intruding on one's privacy, to prevent unwanted social contacts: in brief, to walk alone in a crowd.

We found that the conception of "cocooning" served us well. Inter-personal relations changed very significantly as the experiment wore one. Both Strickland and Stow report a sharp drop in group activity for the latter parts of both experiments, although this does not mean that the groups' inter-actions were fewer or that group solidarity lessened.

Cocooning signifies withdrawl. Its ultimate manifestations may well be regarded as sleep. Less than that, there are varying shades of withdrawl available differentially to human beings, such as cat-napping, immobilization, conscious relaxation of attention, dissociation. In general, the mechanism is a dampening of social stimuli accepted. The condition is of course not incompatible with a high degree of general social awareness or with a high intensity of social disturbance on the part of the cocooner.

We found some evidence to support the surmise that cocooning is correlated with severity of confinement.

The demands of psychic space and cocooning foster a negative attitude toward overt or explicit methods of conflict resolution.

In a sense, these phenomena are part of the individual's natural efforts to resolve or dissolve conflict on an individual basis. Added to that, there seems to be a social factor implicit in the age-old wisdom that conflict should be ignored if possible. Further, there is probably a cultural basis in Americans in favor of ad hoc and, if possible, even unconscious adjustment. These appear to be following an unexpressed rule that much inconvenience should be suffered and much informal griping may be indulged in before formal and explicit complaint should be resorted to.

We found our subjects unwilling to submit their own differences to adjudication, inexpert when forced by superior authority or adverse circumstances to resort to formal adjudication, but, contrariwise, willing to adjudicate hyopthetical disputes.

We found that the subjects in Penthouse III readily responded to directives to consider hypothetical cases in a pro-con-decision-maker format. We had no opportunity to rotate roles. Since the societies were composed solely of peer members we make no reference to what might have happened had a social hierarchy existed or been imposed.

We found that we were unable to persuade the subjects to devise conscious techniques for settling their internal differences. They preferred to allow tensions to be dissipated in any form rather than create adjudicatory machinery for conflict resolution. There was better success at inducing the subjects to act as mediation or conciliation boards if the subject matter of the disputes was hypothetical.

We found that the subjects became increasingly chary about approaching "the authorities" with their complaints.

In the course of discussing and deciding problems submitted to them, we observed various devices used by subjects: for example, "stultification," as where an argument is used against its original proponent to point to a result he doesn't want; "pseudo-consensus," as where a plausible sounding summary of the members' views cleverly imports the speaker's bias as though the group had already endorsed it, which they had not.

We found a strong tendency on the part of all the subjects to avoid and evade decision-making, sometimes openly repudiating decision-making tasks, sometimes employing intellectually fancy techniques for begging the question. We observed various techniques used by the subjects in their group life to maintain a minimum level of group solidarity and to control the pull and tug of personal interests. Among these techniques were overt consensus-declaration, shows of force, legislation, abandoment of grievances, and public denial of existing conflicts (solidarity-invocation).

We found a division of labor among the subjects such that those most prominent in the informal and affectional life of the subjects' peer group were not the ones most prominent in its formal work and in confrontations with nonpeers and with authorities. This points to a rudimentary but basic distinction between the repair work of an emotional or affectional sort which tends to <u>dissolve</u> conflict as opposed to the necessary conscious realization that some demands, some conflicts must be pressed to <u>resolution</u>.

Much study remains to be done on what psycho-social measures are available for detecting these differences among individuals, to say nothing of investigations to determine what might be an optional division of labor between the two types...

We recommend that the attention of authorities in charge of space flight be sharply drawn to the almost total state of ignorance that exists on how confined societies of long duration can be taught to devise conflict-resolving techniques and other rules for their own governance.

We found that the subjects in these confined micro-societies were inclined to compensate for their deprivations by certain "deviant" behaviors which were not discussed in this report (Reference 3). We recommend that studies of prolonged confinement be made by social anthropologists and sociologists to attempt to determine the extent to which these deviant behaviors are the result of confinement and how they may be ameliorated...

O. Balance Data

The only definite findings presented to this point in the report that can be attributed to protein depletion of 15 to 18 days duration have been the marked decrease in the blood urea nitrogen, the decrease in urinary calcium, and the probable decrease in urinary magnesium. During the periods of observation, both at zero-protein and at low-protein intake, no other biochemical, physiological, work performance, psychological, or socio-psychological alteration directly due to altered protein intake have been noted. Therefore, it would appear that the most significant operational criteria for minimum protein requirement of man tested in these experiments would be the maintenance of protein equilibrium under the experimental conditions as outlined above.

The nitrogen intake and major losses in Study #1 are presented in Table 87 and are shown in Figures 28a to 28d. Examination of the data reveals the fluctuation to be expected in balance studies even on formula-type diets. It is also rather interesting to note the immediate effect of even small variations in dietary protein. These variations were brought about by changes of lot of formula during the course of the experiment. It is rather gratifying to note that in subjects 0101 and 0103, when the protein was withdrawn from the diet, a new equilibrium was reached quite rapidly.

The daily urinary nitrogen excretion of subjects 0101 and 0103 during period 3 and part of period 4 is shown in Table 88. It can be seen that the minimal nitrogen excretion was reached after about the sixth to eighth day and thereafter remained quite constant. This is a very important finding and suggests that extremely long-term observations of protein balance before equilibrium conditions can be said to be achieved or at least nearly approached is not nearly as necessary as had been suggested before this study was instituted. Equilibrium appeared to take place very rapidly and during the final phases of the periods of observation appeared to show less fluctuations on a day-to-day basis than were observed in the control period.

The converse was also observed in the subjects during protein repletion during period 4. The subjects retained nitrogen very efficiently; and within the first 6 to 9 days of the metabolic period again were close to their previous control values and certainly had achieved control levels by the end of the major metabolic period. They appeared to retain nitrogen very efficiently and were able to replace the nitrogen lost during the preceeding 18-day, protein-free period. The summary of the 60-day nitrogen balances is shown in Table 89. The partitions of the losses can be seen.

NITROGEN INTAKE AND MAJOR LOSSES (g/day)

	Subject	Intake	Urinary	Fecal	Integumentary	Balance
Test Period A, I: Days 4-9	0102	12.13	11.00	1.07	.13	-0.07
	0104		10.51	1.26	.17	0.19
	0103		10.11	1.61	.15	0.26
	0101		11.12	1.22	.08	-0.29
Average		12.13	10.69	1.29	.13	0.02
Days 10-15	0102	12.13	9.89	1.40	.10	0.74
	0104		10.72	1.23	.22	-0.04
	0103		9.34	1.66	.19	0.94
	0101		10.21	1.11	.10	0.71
Average		12.13	10.04	1.35	.15	0.59
Test Period A, II: Days 4-9	0102	13.28	10.59	1.18	.12	1.39
	0104		10.89	0.82	.15	1.42
	0103		10.07	0.90	.17	2.14
	0101		9.81	1.15	.09	2.23
Average		13.28	10.34	1.01	.13	1.80
Days 10-15	0102	13.28	11.25	0.94	.12	0.97
	0104		10.76	0.78	.17	1.57
	0103		9.92	1.23	.14	1.99
	0101		10.24	1.07	.10	1.87
Average		13.28	10.54	1.01	.13	1.60
Test Period B, III: Days 4-9	0102	13.28	10.40	0.74	.09	2.05
	0104	13.28	11.41	0.79	.15	.93
	0103	0.62	2.68	0.58	.08	-2.72
	0101	0.62	2.91	0.88	.06	-3.23
Days 10-15	0102	13.28	11.02	1.45	.11	.70
	0104	13.28	11.94	0.67	.18	.49
	0103	0.62	2.47	0.90	.10	-2.85
	0101	0.62	2.37	0.97	.07	-2.79
Recovery Period, IV: Days 4-9	0102	13.85	11.12	1.14	.16	1.43
	0104	13.85	11.92	0.60	.17	1.16
	0103	14.13	9.29	0.88	.15	3.81
	0101	14.13	9.46	1.24	.09	3.34
Days 10-15	0102	13.46	11.43	1.72	.16	.15
	0104	13.46	12.17	0.72	.21	.36
	0103	13.46	10.00	1.32	.17	1.97
	0101	13.46	10.07	1.85	.10	1.44

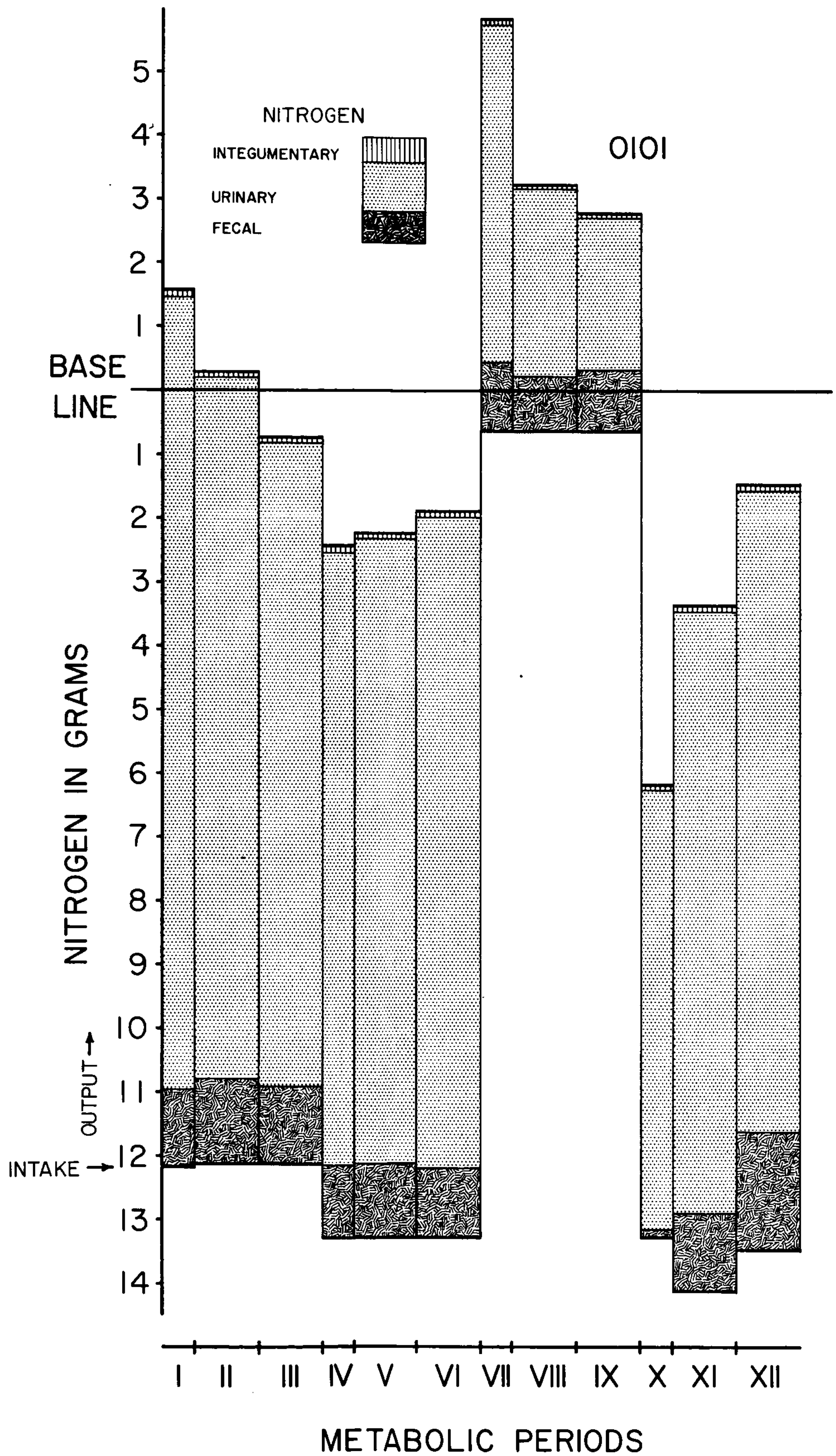

FIG. 28a STUDY ♀: NITROGEN BALANCE PER METABOLIC PERIOD

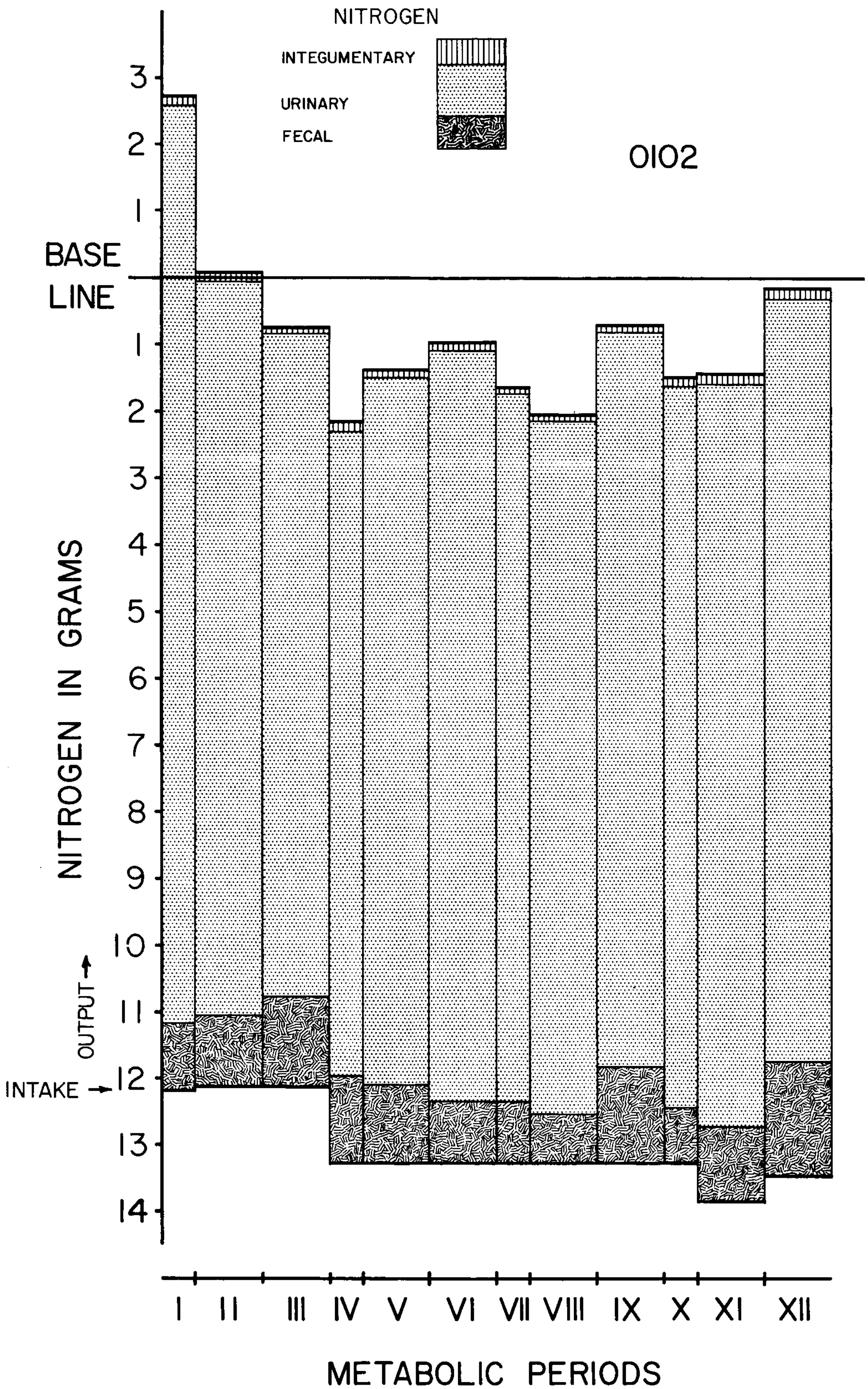

FIG. 28b STUDY I: NITROGEN BALANCE PER METABOLIC PERIOD

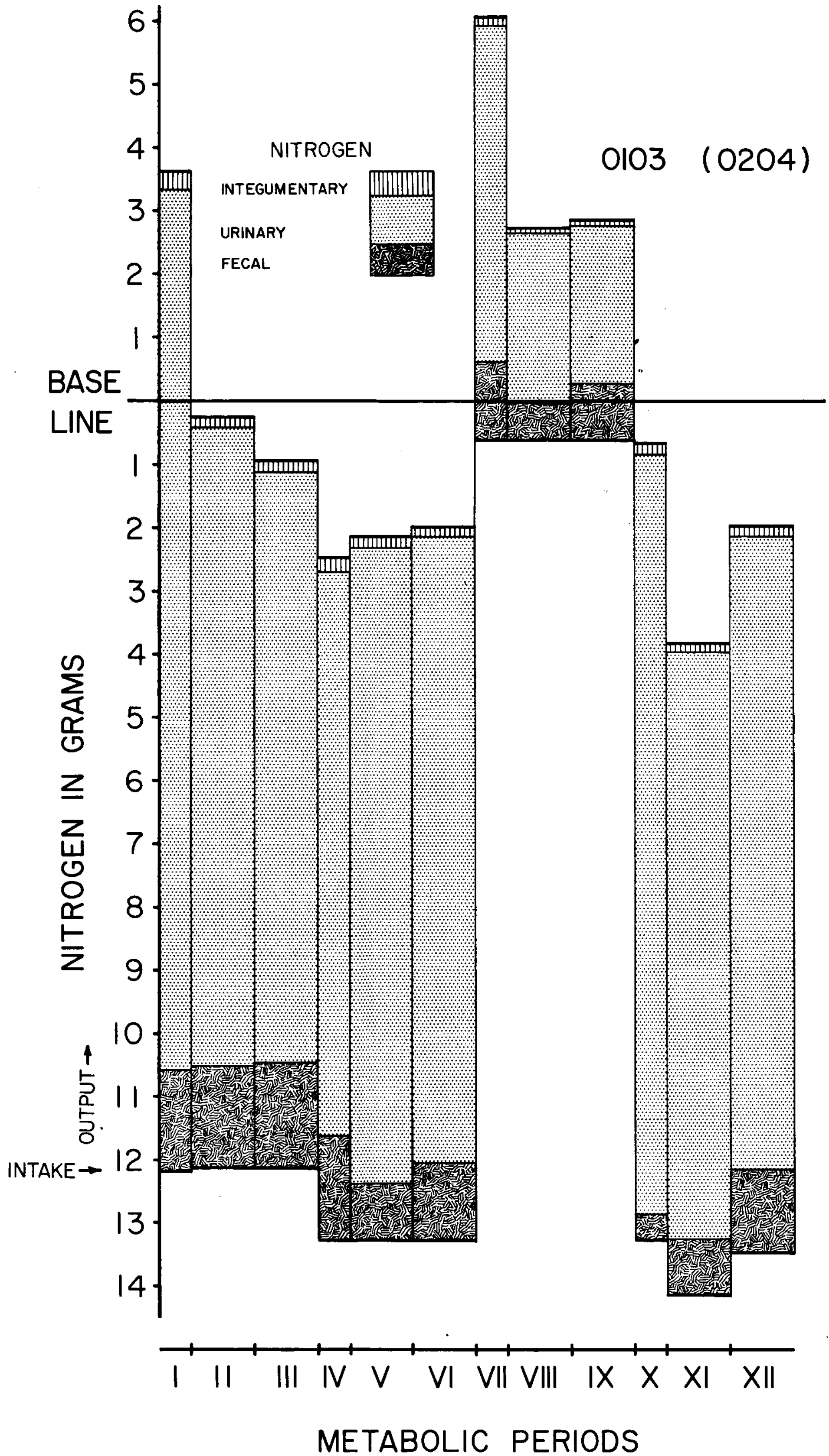

FIG. 28c STUDY I: NITROGEN BALANCE PER METABOLIC PERIOD

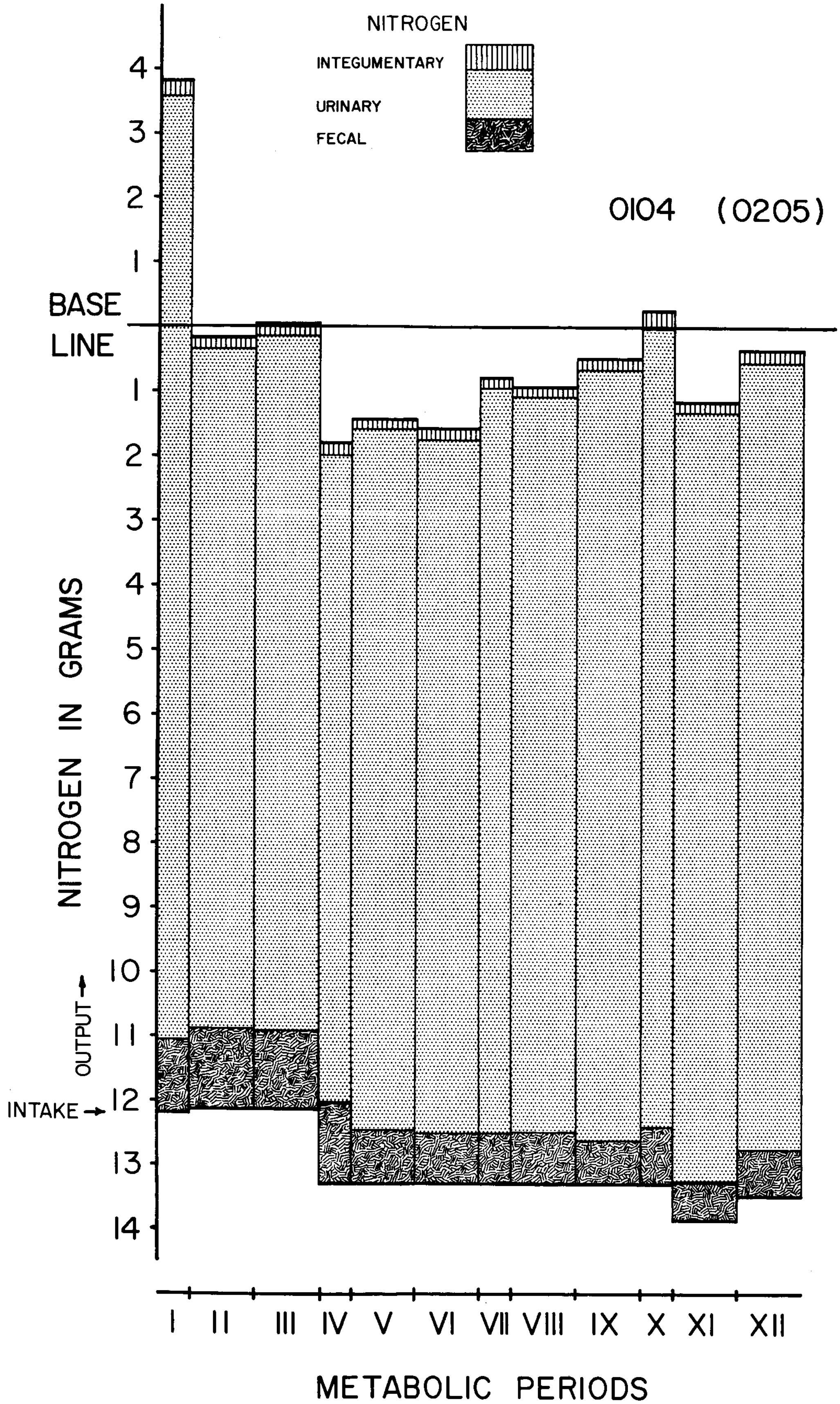

FIG. 28d STUDY I: NITROGEN BALANCE PER METABOLIC PERIOD

DAILY URINARY NITROGEN EXCRETION, GM.

Subject:	0103	0101
Period III, Day 1	7.58	7.00
2	4.71	4.66
3	3.66	4.20
4	2.61	3.35
5	3.62	2.54
6	2.76	3.50
7	2.36	2.48
8	2.38	3.06
9	2.33	2.52
10	2.46	2.13
11	2.31	2.61
12	2.50	2.32
13	2.54	2.28
14	2.47	2.69
15	2.55	2.20
Period IV, Day 1	4.39	5.31
2	6.34	5.35
3	7.36	7.51
4	8.16	8.00
5	8.97	7.85
6	10.63	11.18
7	9.55	10.16
8	9.10	9.70
9	9.32	9.91

SIXTY-DAY NITROGEN BALANCE

NITROGEN SOURCE	SUBJECT 0102	0104	0103	0101
	GM. PER 60 DAYS			
Dietary	784.23	784.23	596.01	596.01
Urinary	655.21	686.47	476.85	497.40
Fecal	70.40	53.25	69.23	70.24
Integumentary	9.24	11.10	9.12	5.52
Samples				
Saliva	(0.06+)	0.06	0.05	0.05
Semen	0.25	0.27	0.33	0.23
Blood	4.77	4.37	4.69	4.76
Balance	+ 44.30	+ 28.71	+ 35.74	+ 17.81
	GM. PER DAY			
Balance	+ .743	+ 4.78	+ .595	+ .296
	% OF INTAKE			
Urinary	83.54	87.53	80.00	83.45
Fecal	8.98	6.79	11.62	11.78
Integumentary	1.18	1.41	1.53	0.93
Samples	0.65	0.60	0.85	0.84
Unaccounted	5.65	3.66	6.00	2.99

Urinary loss, as is well known, is the major pathway. The percent lost in the urine varies between individuals, and much of the variation is compensated for by difference in fecal excretion. The integumentary losses contribute a relatively small but significant proportion of the total. There is considerable variation in integumentary losses between various individuals as noted previously; however, the losses are quite constant for a given individual. The samples of semen and blood withdrawn for analytical purposes in the course of the experiment constituted an even smaller proportion of the losses.

All subjects during the course of the experiment appeared to be in positive nitrogen balance. All carefully controlled balance studies conducted on normal individuals revealed this persistent negative nitrogen balance, undoubtedly due to unaccounted losses, most likely integumentary, or at times due to methodological errors. These losses range from about 3 to 6 percent of the intake in our data, or in absolute figures between about 300 and 700 mg of nitrogen per day. The data for subjects 0101 and 0103 reveals that the measured endogenous nitrogen loss on an approximately 3100 Kcal intake is about 2.8 g/day. However, in view of the fact that there are unaccounted losses of about 450 mgm, a corrective factor equal to this amount must be introduced. It is estimated therefore that in the case of these subjects (0101 and 0103) the minimum endogenous nitrogen loss is approximately 3.25 g. This was true in both of these subjects, even though there was a 5 kg difference in weight between the two. The calculated nitrogen excretion in relation to basal metabolism for subject 0101 is 1.7 mg of nitrogen per basal Kcal/day and for subject 0103 is 2.2 mg of nitrogen per basal Kcal/day.

An attempt was made to account further for the unexplained nitrogen loss in our data. Analysis of our methods revealed the following as possible added sources of losses: 1) incomplete consumption of the diet, noted when it appeared that small portions of the diet would remain in the subjects' eating utensils; 2) loss of saliva when occasionally some of the subjects would spit after brushing their teeth instead of swallowing; 3) variable losses occurring on toilet paper, since this material was not saved during the course of the experiment; 4) variation in method of preparation of urine in which the volume was measured directly or calculated from a combination of weight and specific gravity; 5) possibility of a persistent underestimation of nitrogen in Kjeldahl determinations of urine; 6) possibility of incomplete integumentary losses which has been commented upon; 7) gaseous losses through gastrointestinal tract or respiratory system. Most of these errors would probably represent a relatively constant percentage of nitrogen intake, rather than a fixed amount. Therefore the losses would appear greater when nitrogen intake was high than when nitrogen intake was low.

In order to minimize these potential errors, changes were instituted either before starting or early in the course of Study #2: 1) at the completion of consumption of the formula subjects were required to rinse their utensils until clear with distilled water, swallowing all of the water; 2) subjects were carefully instructed that all saliva was to be swallowed; 3) toilet paper was saved to determine loss by this route, but unfortunately the analysis was impossible due to large excess cellulose present; 4) urine was measured into a volumetric flask of sufficient volume to allow the collecting vessel to be thoroughly rinsed.

In Study #2 an attempt was made to again determine the minimum endogenous protein loss and to then administer protein at approximately that level, or at approximately 3.25 g (which was established as the corrected minimum endogenous nitrogen loss in Study #1). It was postulated that this latter quantity of protein of high biological value should replace endogenous losses and result in nitrogen equilibrium in the presence of adequate calories. The results of these studies are shown in Table 90 and Figures 29a through 29f. The control data appears to show less variation than that observed in Table

It is interesting to note, however, the effect of even small fluctuations in nitrogen and/or caloric intake as noted during periods 7, 8, and 9. During these times, due to an inadvertent change in formula, the protein level and caloric intake were decreased, resulting in a negative nitrogen balance during these periods of lower intake which was compensated for when protein was increased again. When the corrected balance figures are calculated, it is seen that the 2 control subjects were in virtual metabolic balance. It is also seen that the minimum endogenous protein excretion is at the same level as seen in Study #1. There is slight variation from individual to individual. Again, when these values are expressed as nitrogen excretion in relation to basal metabolism, the values for subjects 0203, 0204, 0205, and 0206 are as follows:

NITROGEN LOSS PER BASAL Kcal/day

Subject	Endogenous Nitrogen Loss (Last 6-day Period)	Basal Kcal (per 24 hrs)	Nitrogen Loss (per Kcal/day)
0203	-3.45 g	1850	1.9 mgm
0204	-2.41 g	1780	1.4 mgm
0205	-3.04 g	1920	1.6 mgm
0206	-2.89 g	1630	1.8 mgm

CORRECTED NITROGEN BALANCE, g/day
BY MAJOR METABOLIC PERIOD

Subject	Period	Intake	Approximate Output Urinary	Approximate Output Fecal	Approximate Output Total	Approximate Balance	Output Integumentary	Output Total	Corrected Balance
0201	I	12.38	11.11	1.24	12.35	.03	.201	12.55	- .17
	II	12.38	10.12	1.09	11.21	1.17	.173	11.38	1.00
	III	11.11	10.96	.83	11.79	- .68	.144	11.93	- .82
	IV	11.37	9.78	.97	10.75	.62	.194	10.94	.62
	V	12.37	10.49	1.39	11.88	.49	.190	12.07	.30
0202	I	12.38	12.02	1.42	13.44	-1.06	.166	13.61	-1.23
	II	12.38	10.85	1.57	12.42	- .04	.187	12.61	- .23
	III	11.37	9.99	1.56	11.55	- .18	.149	11.70	- .33
	IV	11.37	9.82	1.37	11.19	.18	.187	11.38	- .01
	V	12.37	9.67	1.86	11.53	.84	.147	11.68	.69
0203	I	12.38	12.01	1.11	13.12	- .74	.153	13.27	- .89
	II	.64	3.65	1.07	4.72	-4.08	.103	4.82	-4.18
	III	3.49	3.38	1.12	4.50	-1.01	.089	4.59	-1.10
	IV	3.55	2.78	1.26	4.04	- .49	.114	4.15	- .60
	V	12.37	8.42	1.26	9.68	2.69	.146	9.83	2.54
0204	I	12.38	9.78	.86	10.64	1.74	.182	10.82	1.56
	II	3.84	3.64	.98	4.62	- .78	.123	4.74	- .90
	III	11.11	8.16	.92	9.08	2.03	.155	9.24	1.87
	IV	.60	2.67	.89	3.56	-2.96	.122	3.68	-3.08
	V	12.37	7.11	1.33	8.44	3.93	.174	8.71	3.66
0205	I	12.36	11.51	.70	12.21	.15	.204	12.40	- .04
	II	.64	3.49	1.05	4.54	-3.90	.156	4.70	-4.06
	III	3.49	3.46	1.03	4.49	-1.00	.161	4.65	-1.16
	IV	3.54	2.86	1.11	3.97	- .43	.154	4.12	- .58
	V	12.39	6.82	.80	7.62	4.77	.190	7.81	4.58
0206	I	12.38	10.06	.78	10.84	1.54	.136	10.98	1.40
	II	.64	2.94	1.06	4.00	-3.36	.082	4.08	-3.44
	III	11.36	7.26	.80	8.06	3.30	.132	8.19	3.17
	IV	3.52	3.60	.95	4.55	-1.03	.106	4.66	-1.14
	V	12.35	8.80	.84	9.64	2.71	.146	9.79	2.56

*Head hair, nails, skin, sweat, and beard.

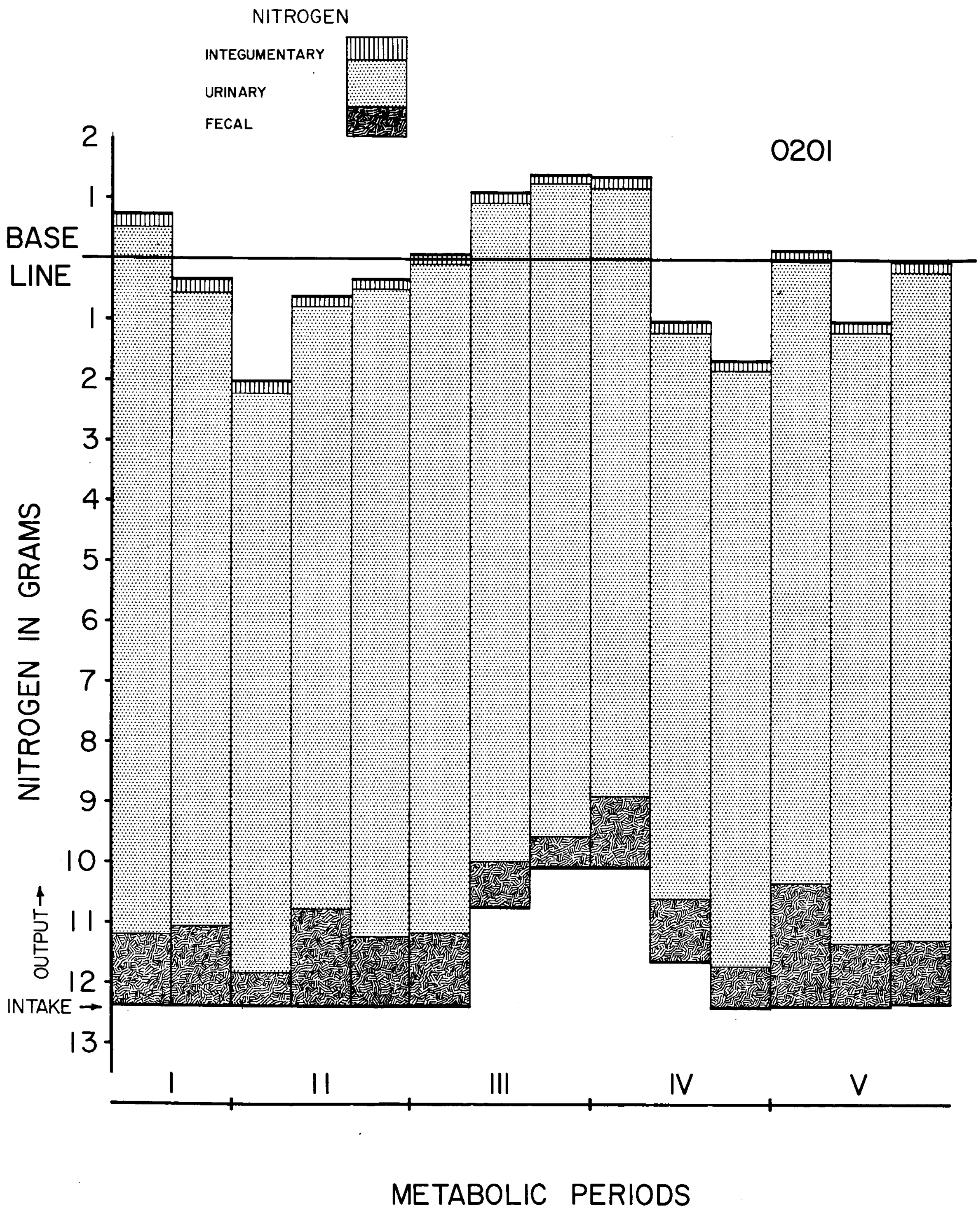

FIG. 29a STUDY 2: NITROGEN BALANCE PER METABOLIC PERIOD

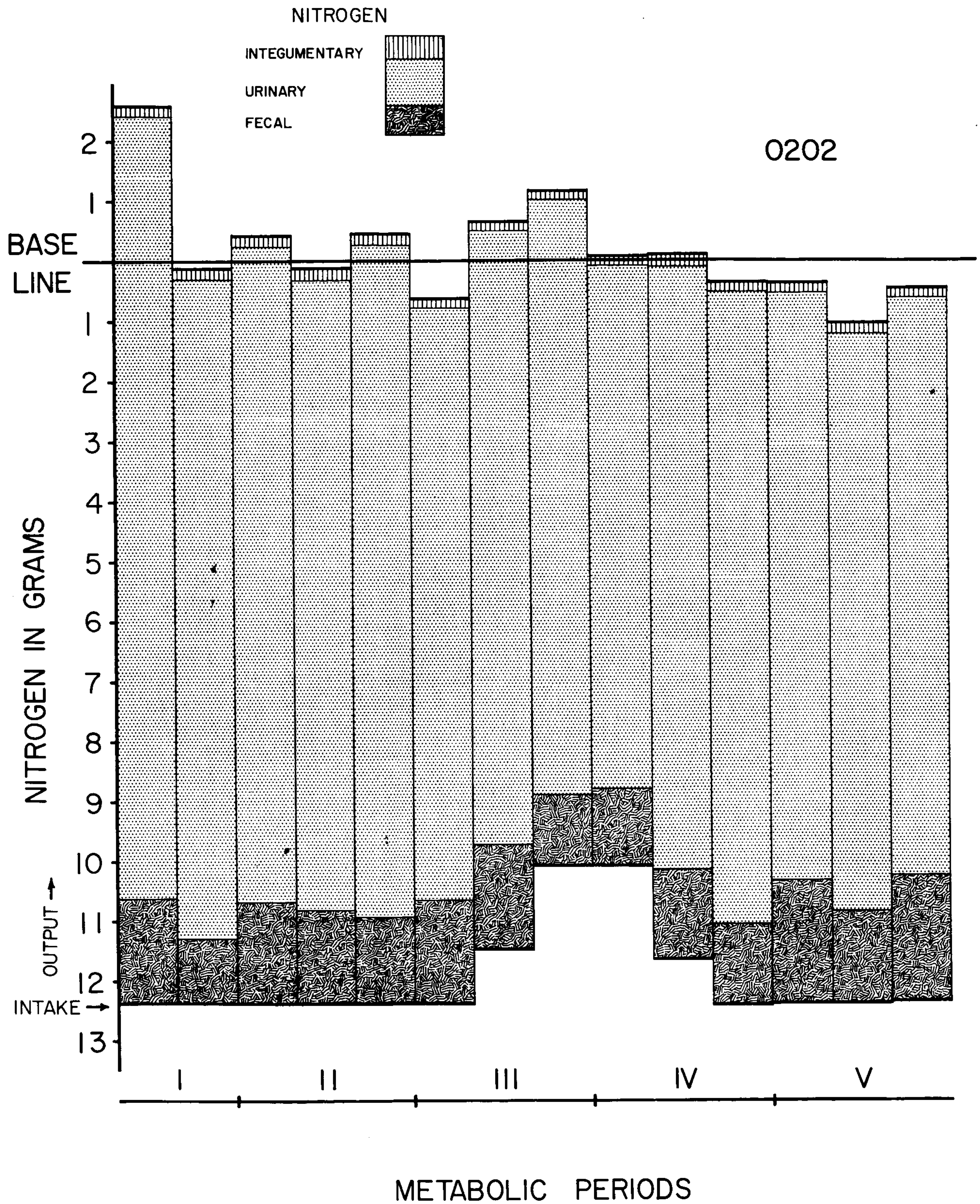

FIG. 29b STUDY 2: NITROGEN BALANCE PER METABOLIC PERIOD

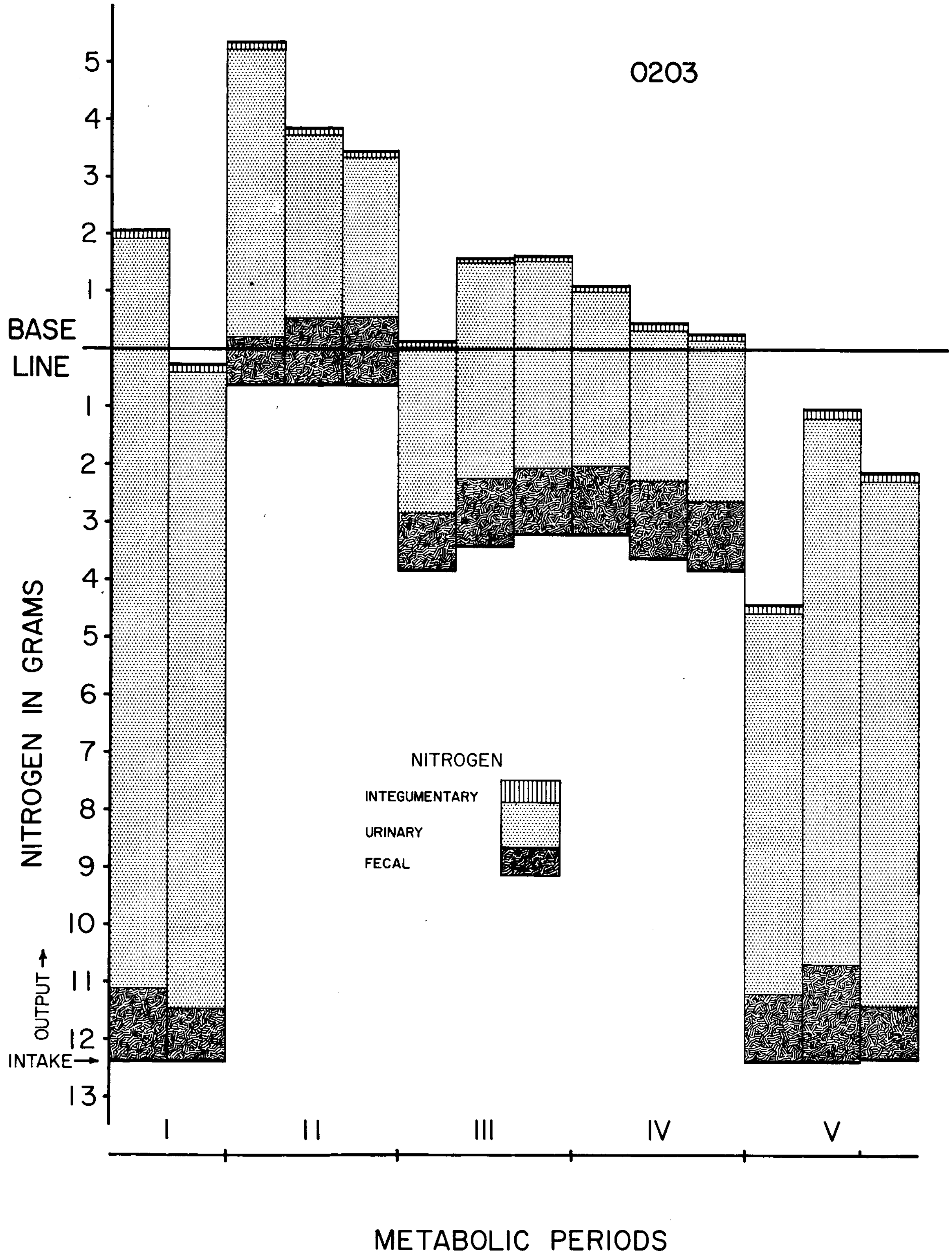

FIG. 29c STUDY 2: NITROGEN BALANCE PER METABOLIC PERIOD

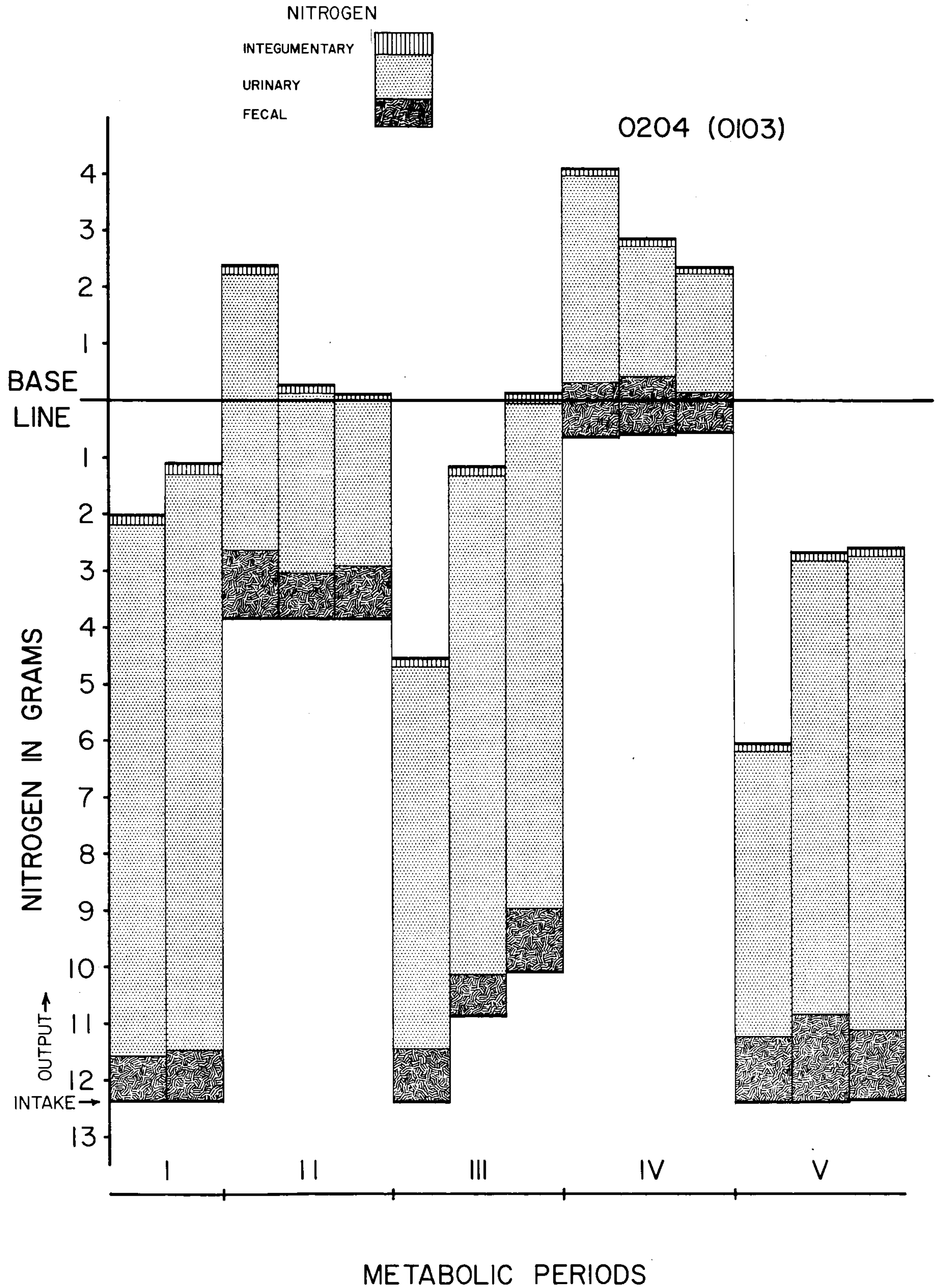

FIG. 29d STUDY 2: NITROGEN BALANCE PER METABOLIC PERIOD

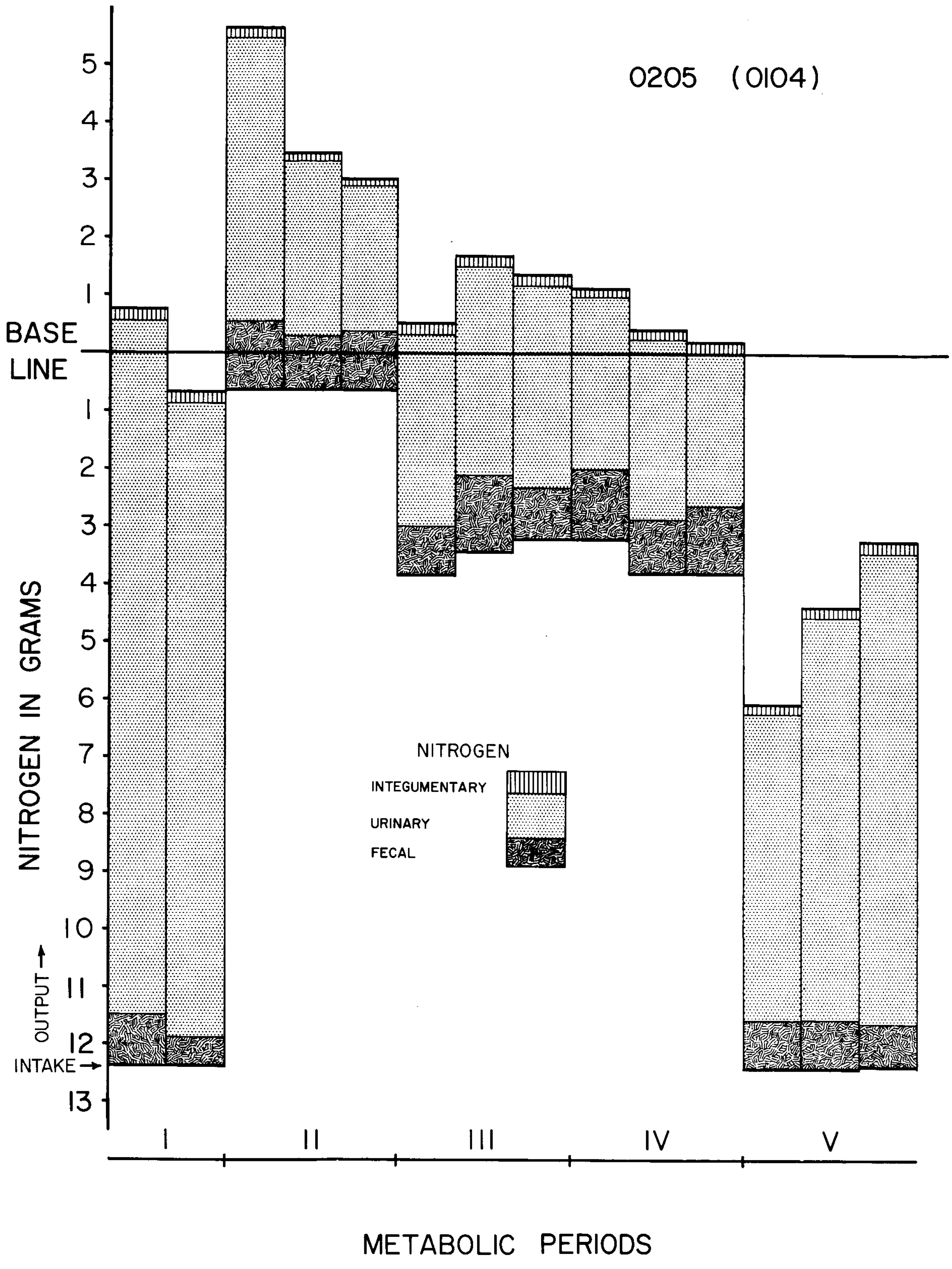

FIG. 29e STUDY 2: NITROGEN BALANCE PER METABOLIC PERIOD

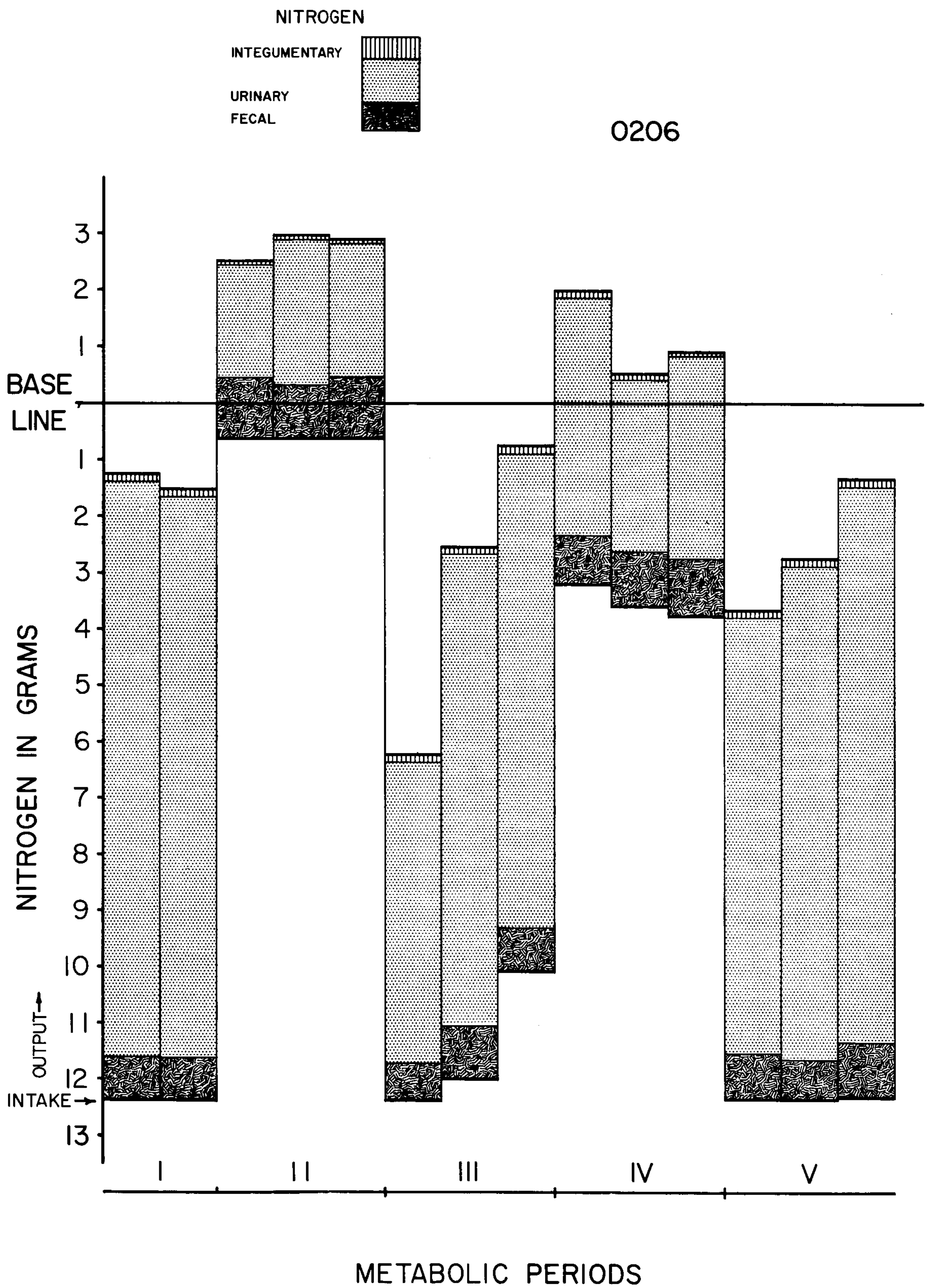

FIG. 29f STUDY 2: NITROGEN BALANCE PER METABOLIC PERIOD

When an attempt was made to maintain nitrogen equilibrium by administering protein at approximately 3.25 g nitrogen level, which is the corrected minimum endogenous nitrogen loss, the values are as shown in Table 91 for individuals 0203, 0204, 0205, and 0206. Values are presented both in terms of the final 12-day and final 6-day metabolic periods. It is seen again that equilibrium is established quite rapidly, although there is some carry-over in the second 6-day metabolic period so that in general values for the last 6-day period are lower than those of the total 12-day period.

It can be seen from this data that at this level of protein and caloric intake nitrogen equilibrium has not been maintained. The individuals are in balance or in very slightly negative balance. In view of the control data, however, this represents a persistent negative nitrogen balance of approximately 250 to 500 mg/day.

Study #3 served to increase the amount of data available on control subjects receiving a formula diet and to utilize this as a comparison of nitrogen equilibrium obtained with individuals receiving more conventional type foods as prepared for the Gemini flights. The Balance data in Study #3 differs from the previous 2 studies in that 4 of the subjects fed the formula diet containing 75 g of protein were in negative nitrogen balance, as were 5 of the 6 Gemini subjects despite daily protein intakes of 100 g/day (Table 92 and Figures 30a through 30f).

In Study #3 the caloric intake was reduced, the formula group receiving about 2800 Kcal and the Gemini group about 2768 Kcal. The degree of negative nitrogen balance between the formula and the Gemini groups did not seem significant, although average daily nitrogen loss was 570 mg for the Gemini group and 290 mg for the formula group. The corrected nitrogen balance study in Study #3 has been done for losses of nitrogen through blood samples, hair and nails, and bath and laundry collections for each individual. As noted before, the bath and underwear laundry collection periods were during one 6-day period of the experiment and projected for the entire Study. The usual within-subject variation from 1 collection period to another was noted, but there was no apparent time effect, either in direction or magnitude of balance. In fact, in general the magnitude of variation appeared to be less than in previous studies, particularly with the formula group.

The reason for this apparent negative nitrogen balance observed in Study #3 is unclear. The principal suggestions are: 1) due to a lowering of the caloric intake; 2) due to decreased activity of the subjects since 12 subjects instead of 6 were housed in the Penthouse; and 3) due to the added stress of increased number of subjects living together in a confined physical space.

CORRECTED NITROGEN BALANCE
g/day, BY COLLECTION PERIOD

Subject	Collection Period	Intake	Approximate Output			Approximate Balance	Output		Corrected Balance
			Urinary	Fecal	Total		Integumentary	Total	
0201	1	12.38	11.72	1.18	12.90	- .52	.201	13.10	- .72
	2	12.38	10.50	1.13	11.63	.75	.201	11.83	.55
	3	12.38	9.60	.84	10.44	1.94	.173	10.61	1.77
	4	12.38	9.97	1.59	11.56	.82	.173	11.73	.65
	5	12.38	10.78	1.13	11.91	.47	.173	12.08	.30
	6	12.38	11.08	1.19	12.27	.11	.144	12.41	- .03
	7	10.85	11.00	.77	11.77	- .92	.144	11.91	-1.06
	8	10.09	10.82	.52	11.34	-1.25	.144	11.48	-1.39
	9	10.09	10.08	1.18	11.26	-1.07	.194	11.45	-1.36
	10	11.63	9.39	1.03	10.42	-1.21	.194	10.61	1.02
	11	12.40	9.85	.69	10.54	1.86	.194	10.73	1.67
	12	12.38	10.29	2.04	12.33	.05	.190	12.52	- .14
	13	12.38	10.10	1.05	11.15	1.23	.190	11.34	1.04
	14	12.34	11.07	1.07	12.14	.20	.190	12.33	.01
0202	1	12.38	13.08	1.76	14.84	-2.46	.166	15.01	-2.63
	2	12.38	10.96	1.09	12.05	.33	.166	12.22	.16
	3	12.38	10.90	1.70	12.60	- .22	.187	12.79	- .41
	4	12.38	10.47	1.56	12.03	.35	.187	12.22	.16
	5	12.38	11.18	1.44	12.62	- .24	.187	12.81	- .43
	6	12.38	9.69	1.73	11.42	.96	.149	11.57	.81
	7	11.47	10.21	1.75	11.96	- .49	.149	12.11	- .64
	8	10.09	9.90	1.19	11.09	-1.00	.149	11.24	-1.15
	9	10.09	8.70	1.29	9.99	.11	.187	10.18	- .09
	10	11.63	10.24	1.49	11.73	- .10	.187	11.92	- .29
	11	12.40	10.53	1.34	11.87	.53	.187	12.06	.36
	12	12.38	9.86	1.94	11.80	.58	.147	11.95	.43
	13	12.38	9.58	1.53	11.11	1.27	.147	11.26	1.12
	14	12.34	9.90	2.10	12.00	.34	.147	12.15	.19
0203	1	12.38	13.00	1.28	14.28	-1.90	.153	14.43	-2.05
	2	12.38	11.02	.93	11.95	.43	.153	12.21	.17
	3	.64	5.00	.84	5.84	-5.20	.103	5.94	-5.30
	4	.64	3.18	1.17	4.35	-3.71	.103	4.45	-3.81
	5	.64	2.80	1.19	3.99	-3.35	.103	4.09	-3.45
	6	3.84	2.78	.99	3.77	- .07	.089	3.86	- .02
	7	3.42	3.70	1.19	4.89	-1.47	.089	4.98	-1.56
	8	3.21	3.06	1.17	4.23	-1.02	.089	4.32	-1.11
	9	3.21	3.01	1.20	4.21	-1.00	.144	4.32	-1.11
	10	3.62	2.57	1.37	3.94	- .32	.114	4.05	- .43
	11	3.83	2.77	1.20	3.97	- .14	.114	4.08	- .25
	12	12.38	6.62	1.17	7.79	4.59	.146	7.94	4.44
	13	12.38	9.48	1.69	11.17	1.21	.146	11.32	1.06
	14	12.34	9.15	.92	10.07	2.27	.146	10.22	2.12

continued

Penthouse Study #2
Corrected Nitrogen Balance, g/day, By Collection Period

Table 91
continued

Subject	Collection Period	Intake	Approximate Output: Urinary	Approximate Output: Fecal	Approximate Output: Total	Approximate Balance	Output: Integumentary	Output: Total	Corrected Balance
0204	1	12.38	9.38	.81	10.19	2.19	.182	10.37	2.01
	2	12.38	10.18	.90	11.08	1.30	.182	11.26	1.12
	3	3.84	4.85	1.21	5.06	-1.22	.123	5.18	1.12
	4	3.84	3.18	.80	3.98	- .14	.123	5.18	-1.34
	5	3.84	2.89	.93	3.82	.02	.123	4.10	- .26
	6	12.38	6.75	.93	7.68	4.70	.123	3.94	- .10
	7	10.85	8.91	.71	9.62	1.23	.155	7.84	4.54
	8	10.09	8.92	1.12	10.04	.05	.155	9.78	1.07
	9	.64	3.66	.95	4.61	-3.97	.155	10.20	- .11
	10	.60	2.30	1.02	3.32	-2.72	.122	4.73	-4.09
	11	.56	2.14	.71	2.85	-2.29	.122	3.44	-2.84
	12	12.38	5.04	1.15	6.19	6.19	.122	2.97	-2.41
	13	12.38	7.96	1.58	9.54	2.84	.174	6.36	6.02
	14	12.34	8.32	1.26	9.58	2.76	.174	9.71	2.67
							.174	9.75	2.59
0205	1	12.37	12.04	.89	12.93	- .56	.204	13.13	- .76
	2	12.36	10.98	.50	11.48	.88	.204	11.68	.68
	3	.64	4.95	1.19	6.14	-5.50	.156	6.30	-5.66
	4	.64	3.03	.94	3.97	-3.33	.156	4.13	-3.49
	5	.64	2.50	1.02	3.52	-2.88	.156	3.68	-3.04
	6	3.84	3.31	.86	4.17	- .33	.161	4.33	- .49
	7	3.42	3.59	1.33	4.92	-1.50	.161	5.08	-1.66
	8	3.21	3.50	.89	4.39	-1.18	.161	4.55	-1.34
	9	3.21	2.97	1.22	4.19	- .98	.154	4.34	-1.13
	10	3.60	2.91	.94	3.85	- .25	.154	4.00	- .40
	11	3.80	2.69	1.16	3.85	- .05	.154	4.00	- .20
	12	12.40	5.31	.83	6.14	6.26	.190	6.33	-6.07
	13	12.40	6.98	.84	7.82	4.58	.190	8.01	4.39
	14	12.36	8.18	.74	8.92	3.44	.190	9.11	3.25
0206	1	12.38	10.20	.78	10.98	1.40	.136	11.12	1.26
	2	12.38	9.94	.77	10.71	1.67	.136	10.84	1.53
	3	.64	3.92	1.10	5.02	-4.38	.082	5.10	-4.46
	4	.64	2.54	.97	3.51	-2.87	.082	3.59	-2.95
	5	.64	2.34	1.11	3.45	-2.81	.082	3.53	-2.89
	6	12.38	5.36	.66	6.02	6.36	.132	6.15	6.23
	7	11.98	8.02	.94	8.96	3.02	.132	9.09	2.89
	8	10.09	8.40	.79	9.19	.90	.132	9.32	.77
	9	3.21	4.21	.87	5.08	-1.87	.106	5.19	-1.98
	10	3.61	3.03	.98	4.01	- .40	.106	4.12	- .51
	11	3.76	3.57	1.01	4.58	- .82	.106	4.69	- .93
	12	12.36	7.75	.82	8.57	3.81	.146	8.72	3.64
	13	12.36	8.78	.70	9.48	2.88	.146	9.63	2.73
	14	12.32	9.87	.99	10.86	1.46	.146	11.01	1.31

CORRECTED NITROGEN BALANCE

Subject	Blood Weight	Samples Nitrogen	Average daily nitrogen loss as mg. Blood Samples	Hair & Nails	Bath & Laundry	Corrected Nitrogen Balance, g./day
	g.	g.				
Gemini Group						
0301	212.2	6.971	166	21	70	-0.06
0303	242.1	8.210	195	11	112	-0.72
0304	224.1	7.498	179	28	118	-1.32
0305	218.0	7.392	176	24	113	-1.13
0308	214.0	6.889	164	19	122	-1.10
0312	222.6	7.916	188	15	100	-0.89
Formula Group						
0302	189.7	6.529	155	15	204	-0.94
0306	216.2	7.346	175	20	102	-1.74
0307	245.5	7.890	188	29	126	0.38
0309	213.7	7.462	178	28	136	-0.68
0310	216.3	7.281	173	14	102	0.11
0311	213.5	7.144	170	30	65	-0.66

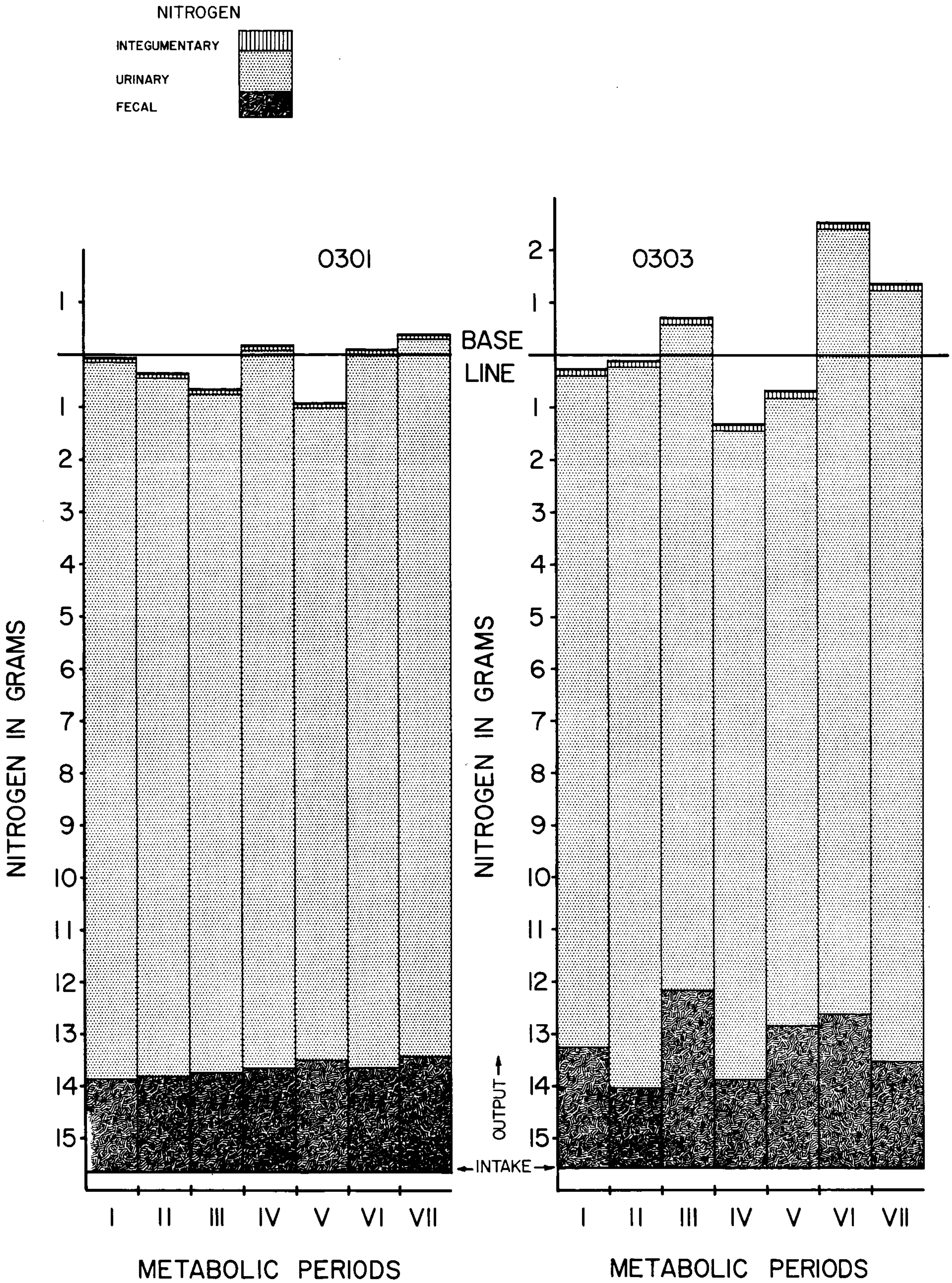

FIG. 30a NITROGEN BALANCE PER METABOLIC PERIOD
STUDY 3, GEMINI SUBJECTS

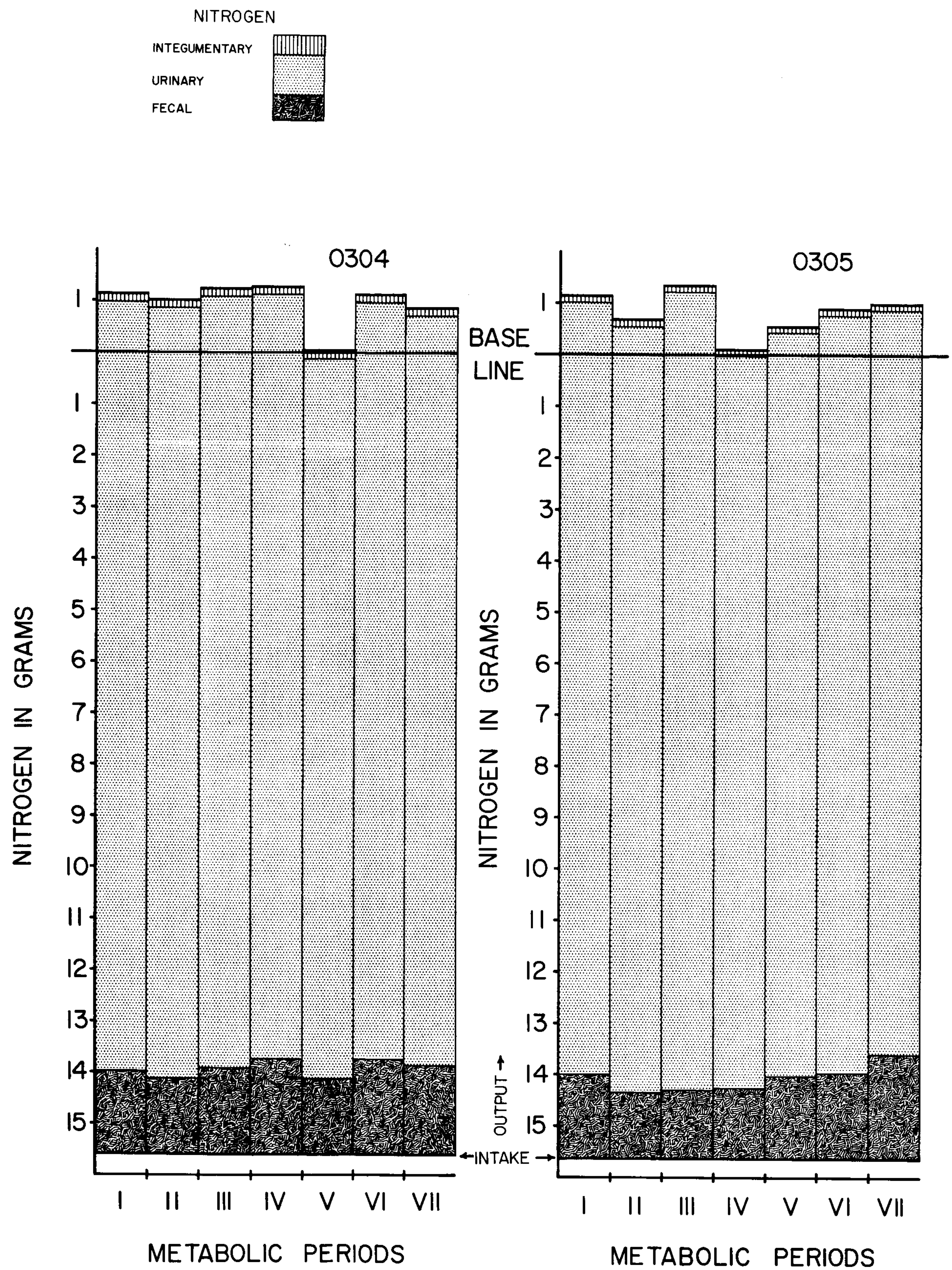

FIG. 30b NITROGEN BALANCE PER METABOLIC PERIOD
STUDY 3, GEMINI SUBJECTS

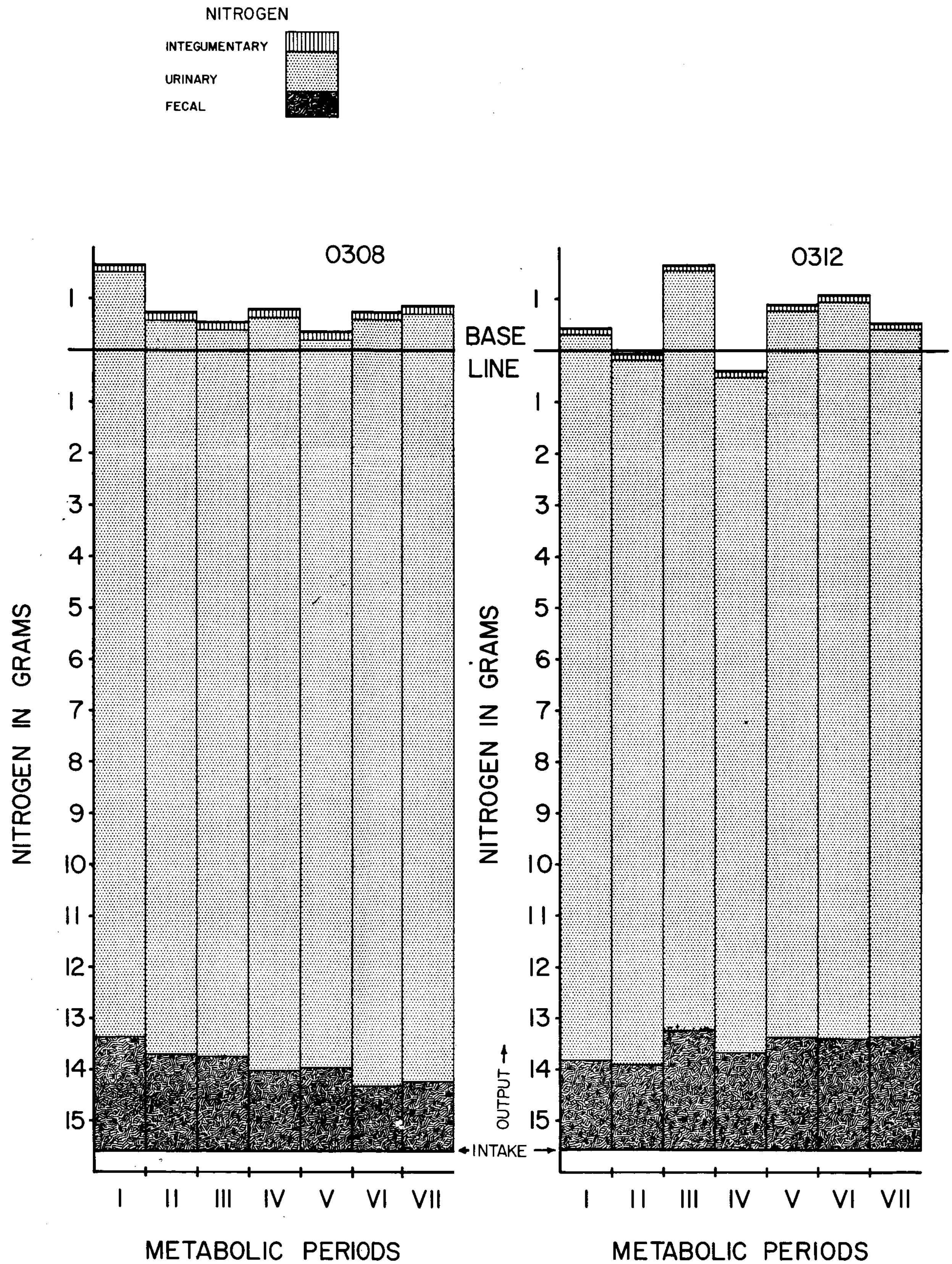

FIG. 30c NITROGEN BALANCE PER METABOLIC PERIOD
STUDY 3, GEMINI SUBJECTS

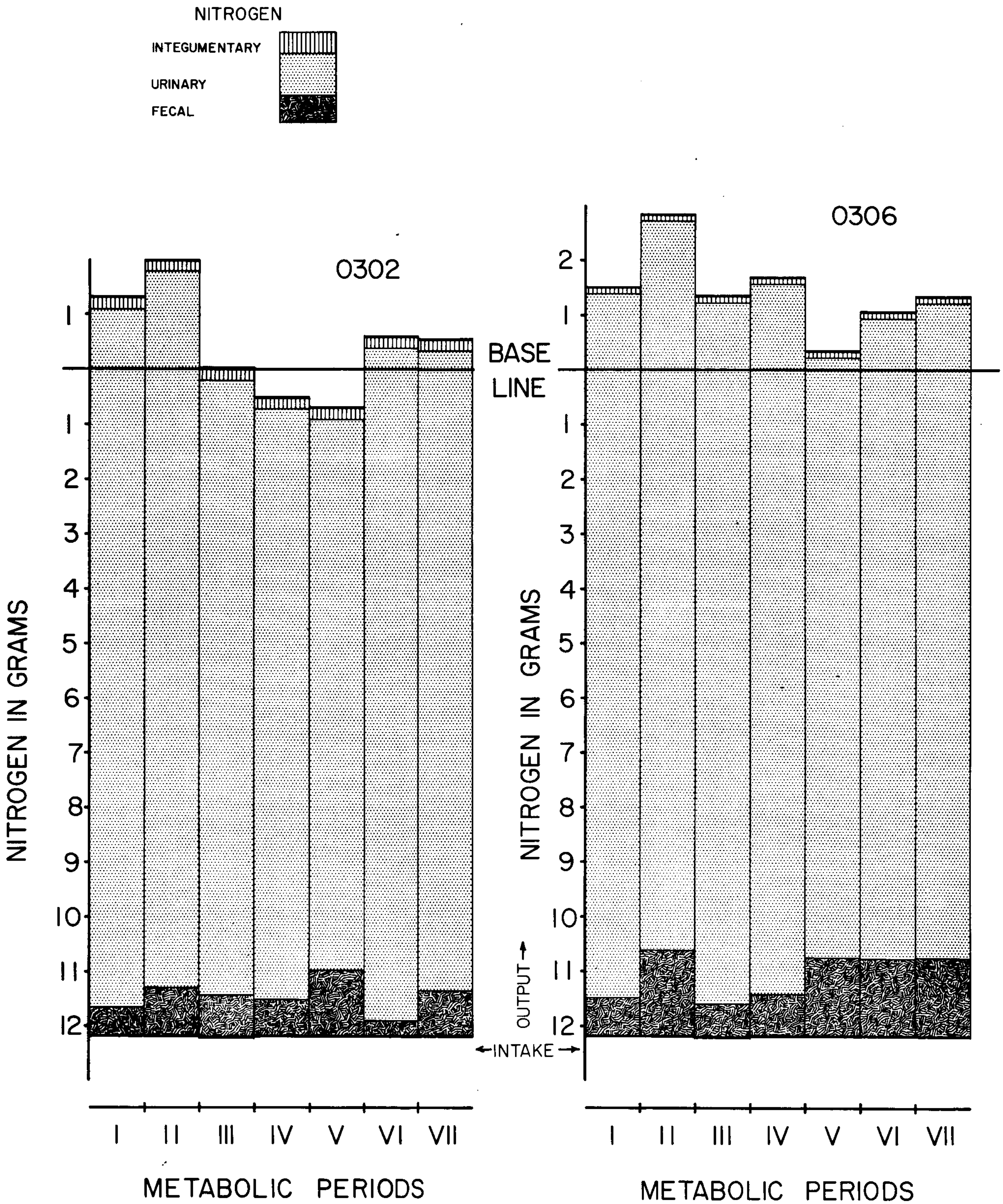

FIG. 30d NITROGEN BALANCE PER METABOLIC PERIOD
STUDY 3, FORMULA SUBJECTS

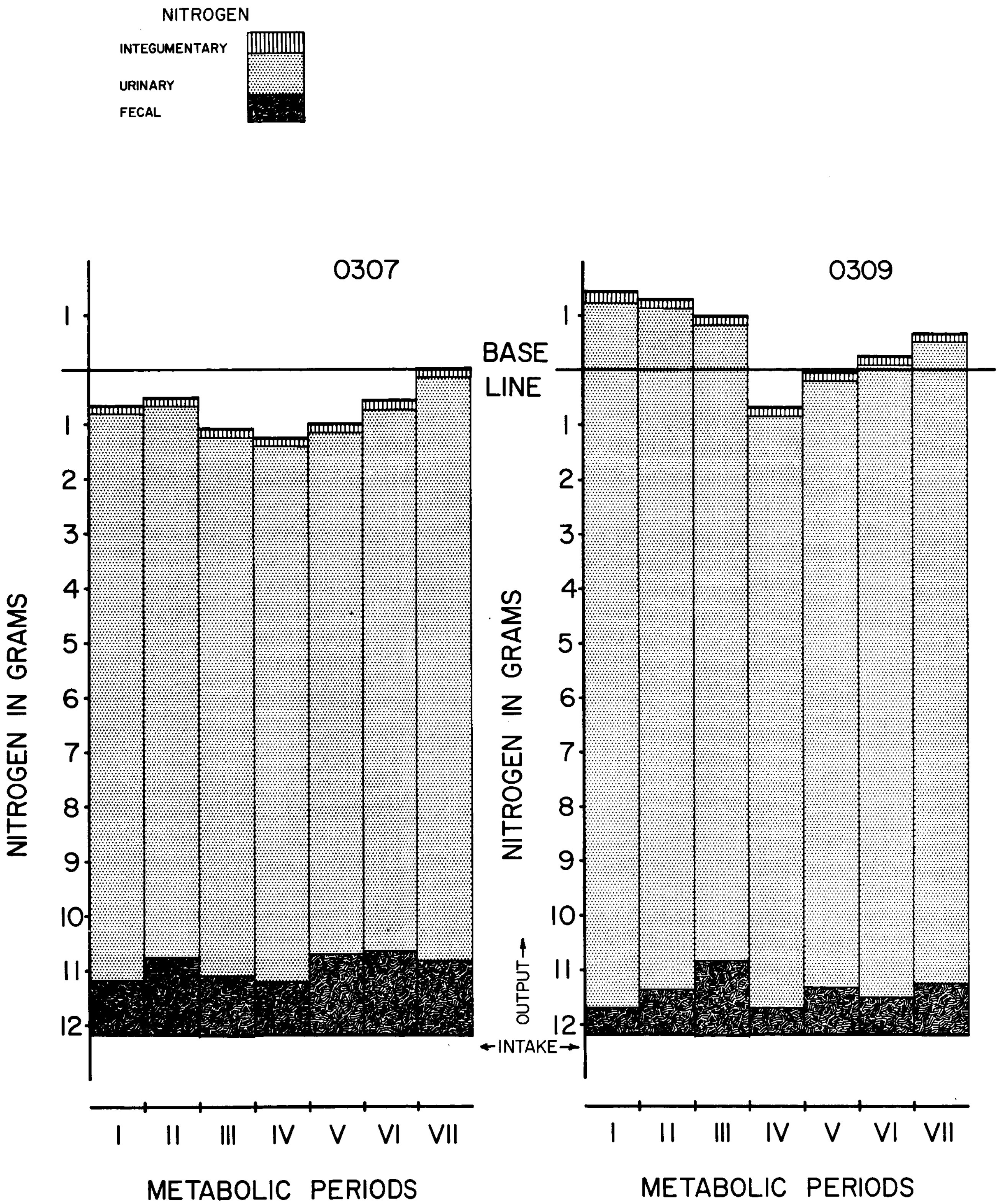

FIG. 30e NITROGEN BALANCE PER METABOLIC PERIOD
STUDY 3, FORMULA SUBJECTS

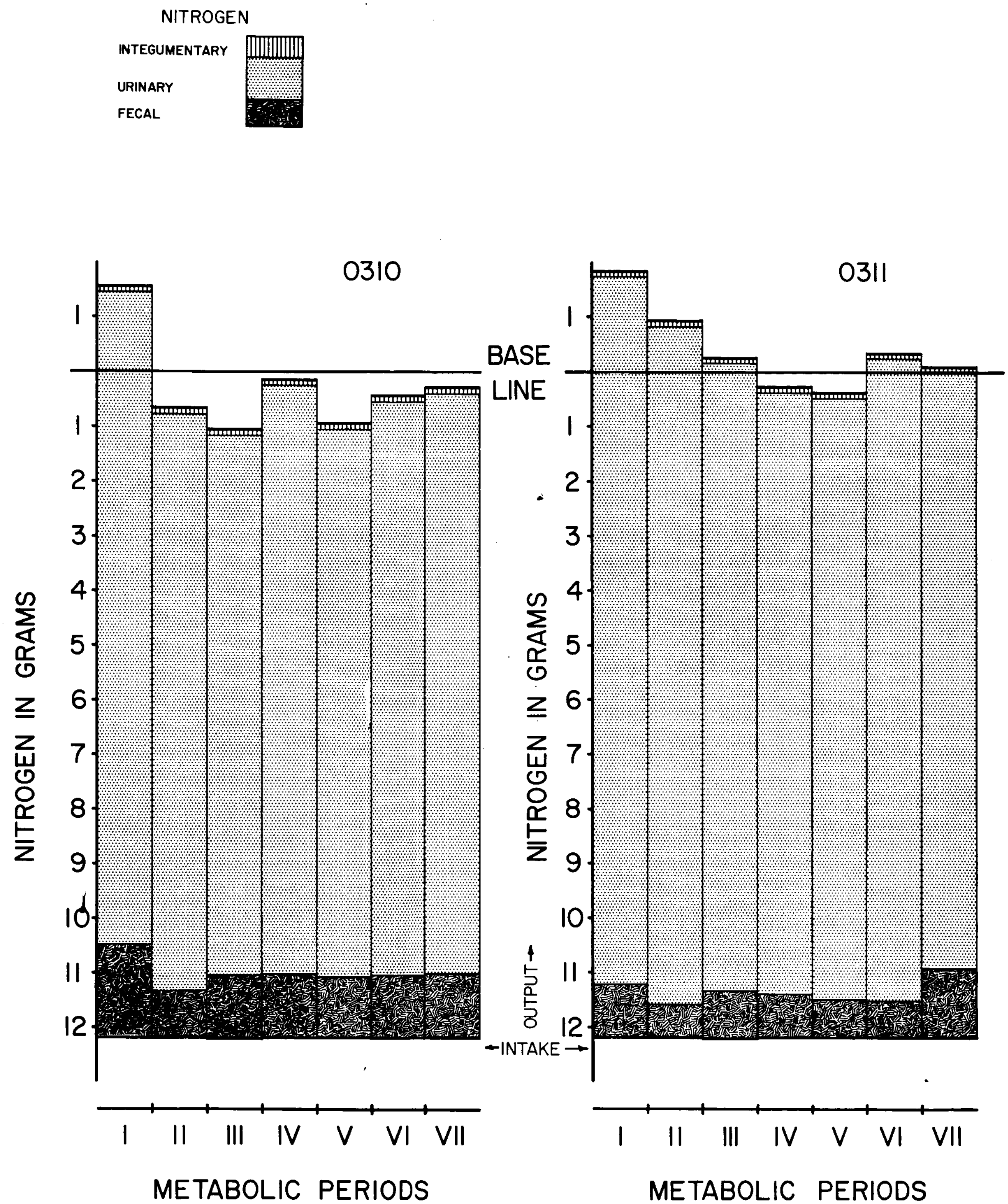

FIG. 30f NITROGEN BALANCE PER METABOLIC PERIOD
STUDY 3, FORMULA SUBJECTS

We have not attempted to correct the other nutrient balances in the same way as nitrogen because we have not made complete estimation of losses of the others in a sufficient number of instances to warrant such correction. It must be recognized, therefore, that all are based on underestimations of loss.

No mineral balances were determined in Study #1. The data from Study #2 shown in Tables 93, 94, 95, and 96.

It is noted that with negative nitrogen balances noted on zero nitrogen intake there is an increase in the negativity of balance of potassium and phosphorus, the major intracellular ions. This increased loss is to be expected with tissue breakdown and the excretion is in reasonable proportion to nitrogen as these minerals occur in tissues. The effects observed at the 3 g nitrogen levels are slight and in general are the same as the control values. No significant effect of dietary nitrogen manipulation is observed in sodium or magnesium balance, and the apparent effect on calcium balance is too variable to draw conclusions.

However, the increased loss of sodium and apparent but variable negativity of sodium is difficult to explain. The increased sodium loss may be due to decrease in extracellular fluid as tissue is depleted to maintain osmolarity. The calcium loss (as well as magnesium loss) may represent in part decreased absorption of these minerals. These certainly demonstrate that with zero protein intake the metabolic effects that can be measured show influences far beyond "chemical" protein alone, but represent marked alterations in tissues and organs.

In the case of Study #3, potassium and phosphorus (the major constituents of soft tissue) were lost in reasonable proportion to nitrogen. The mean calcium balance was slightly negative in the Gemini subjects. The reason for these differences is unclear. Sodium and chloride were apparently retained in both groups, but this is to be expected in view of the relatively large losses of sodium and chloride in sweat (Table 97).

APPARENT EXTERNAL METABOLIC BALANCES BY TREATMENT PERIOD
g/day, AVERAGED BY SUBJECT

Subject	Experiment Days	Nitrogen	Sodium	Potassium	Calcium	Magnesium	Phosphorus
0201	1-84	.35	-.18	.18	.01	-.04	-.11
0202	1-84	.01	-.22	.12	-.14	-.04	-.22
0203	1-12	- .73	-.20	- .03	.00	-.05	-.20
	13-30**	-4.07	-.49	- .80	-.13	-.08	-.38
	31-66*	- .74	-.08	- .12	-.25	-.04	-.17
	67-84	2.69	.00	.27	-.08	-.03	-.05
0204	1-12	1.74	-.42	.28	.14	.06	.01
	13-30*	- .77	-.25	.25	.13	.01	-.03
	31-48	2.03	-.39	.22	-.01	-.04	-.07
	49-66**	-2.96	-.32	-1.00	.06	-.10	-.38
	67-84	3.93	-.04	.38	-.09	-.04	.01
0205	1-12	.16	.32	- .26	.18	.05	-.02
	13-30**	-3.89	-.11	- .18	-.20	-.12	-.40
	31-66*	- .71	.50	- .20	-.07	-.04	-.12
	67-84	4.76	.75	.58	.10	.05	.20
0206	1-12	1.54	-.33	.24	.05	.03	-.09
	13-30**	-3.35	-.87	- .53	-.25	-.14	-.49
	31-48	3.31	-.16	.23	-.02	.03	.09
	49-66*	-1.11	-.12	.33	-.10	-.08	-.20
	67-84	2.71	.15	.32	.08	.00	.14

* 3 g nitrogen intake.
** "Zero" nitrogen intake.

APPARENT EXTERNAL METABOLIC BALANCES
g/day, BY COLLECTION PERIOD

Subject	6-Day Collection Period	Nitrogen	Sodium	Potassium	Calcium	Magnesium	Phosphorus
0201	1	- .51	- .50	- .06	-.20	-.86	-.29
	2	.57	- .13	.24	-.08	-.06	-.22
	3	2.24	.07	.63	.41	.12	.32
	4	.82	- .06	.27	-.11	-.10	-.16
	5	.47	.08	.16	.08	-.06	-.11
	6	.11	- .07	.14	-.06	-.08	-.16
	7	- .91	- .40	.12	.04	-.04	-.08
	8	-1.24	- .73	- .05	.27	.02	-.05
	9	-1.16	- .15	- .40	-.14	-.11	-.28
	10	1.21	- .54	.46	-.06	-.06	-.12
	11	1.86	.14	.47	.15	.05	.18
	12	.05	- .04	.10	-.43	-.21	-.37
	13	1.23	.09	.30	.08	.02	-.01
	14	.20	- .31	.09	.09	.00	-.19
0202	1	-2.45	- .28	- .06	-.39	-.06	-.53
	2	.33	- .10	.24	.08	.09	-.07
	3	- .21	- .23	.63	-.32	-.06	-.26
	4	.35	- .20	.27	-.14	-.03	-.19
	5	- .23	- .13	.16	-.20	-.07	-.29
	6	.80	- .02	.14	-.34	-.08	-.28
	7	- .48	- .68	.12	-.29	-.10	-.35
	8	- .99	- .44	- .05	-.02	-.04	-.30
	9	.10	- .44	- .21	-.04	-.03	-.13
	10	- .10	- .24	- .31	-.05	-.06	-.24
	11	.53	- .28	.39	-.01	-.02	.03
	12	.58	.07	.20	-.13	-.06	-.23
	13	1.27	.10	.47	-.02	-.01	-.06
	14	.67	- .17	.21	-.15	-.11	-.17
0203	1	-1.89	- .26	- .29	-.11	-.07	-.33
	2	.43	- .15	.22	.09	-.04	-.07
	3**	-5.19	- .23	- .70	-.02	-.01	-.28
	4**	-3.70	- .57	-1.01	-.19	-.12	-.46
	5**	-3.32	- .67	- .69	-.17	-.12	-.40
	6*	- .01	.05	.04	-.06	.05	.04
	7*	-1.46	- .27	- .29	-.22	-.10	-.43
	8*	-1.51	- .10	- .32	-.11	-.06	-.11
	9*	- .99	- .28	- .22	-.17	-.09	-.20
	10*	- .31	.04	- .36	-.11	-.02	-.22
	11*	- .13	.10	.40	-.04	-.01	-.12
	12	4.59	- .20	.34	-.11	-.01	-.01
	13	1.21	.28	.04	-.34	-.16	-.33
	14	2.27	- .08	.41	.21	.09	.17

continued

Penthouse Study #2
Apparent External Metabolic Balances

Table 94
continued

Subject	6-Day Collection Period	Nitrogen	Sodium	Potassium	Calcium	Magnesium	Phosphorus
0204	1	2.19	- .86	.09	.20	.08	.07
	2	1.30	- .07	.48	.07	.03	-.06
	3*	-2.21	.15	.30	-.09	-.05	-.21
	4*	- .13	- .95	.14	.03	.07	.12
	5*	.02	.06	.31	.18	-.01	.04
	6	4.70	- .34	.27	.17	.02	.10
	7	1.34	- .24	.29	.06	.00	-.05
	8	.05	- .58	.12	-.28	-.12	-.34
	9**	-3.96	- .30	- .54	.01	-.09	-.23
	10**	-2.71	- .74	-1.35	.24	-.15	-.61
	11**	-2.21	- .52	-1.12	.16	-.06	-.46
	12	6.19	- .02	.51	.03	.01	.14
	13	2.84	.07	.27	-.20	-.07	-.05
	14	2.76	- .18	.36	-.07	-.05	-.06
0205	1	- .55	- .03	- .58	-.02	.00	-.25
	2	.88	.67	- .03	.36	.10	.19
	3**	-5.49	.46	- .52	-.39	-.17	-.49
	4**	-3.32	- .23	- .33	.00	-.08	-.36
	5**	-2.87	- .56	.33	-.20	-.12	-.36
	6*	- .32	.49	- .16	.04	.00	-.10
	7*	-1.49	.50	- .00	-.26	-.06	-.30
	8*	-1.17	.24	- .40	.09	-.04	-.09
	9*	- .97	.22	- .42	-.16	-.10	-.11
	10*	- .28	.80	- .14	.07	.02	-.07
	11*	- .04	.75	- .13	.04	-.04	-.05
	12	6.26	.92	.64	.10	.03	.18
	13	4.58	.78	.83	.13	.08	.18
	14	3.44	.56	.26	.07	.03	.25
0206	1	1.40	- .59	.05	.00	.03	-.15
	2	1.67	- .07	.42	.09	.04	-.03
	3**	-4.37	- .47	- .62	-.26	-.12	-.63
	4**	-2.86	- .68	- .54	-.16	-.12	-.45
	5**	-2.81	-1.46	- .43	-.34	-.20	-.58
	6	6.36	.04	.50	.23	.14	.27
	7	2.66	- .14	.30	-.22	-.03	-.03
	8	.90	- .38	- .10	.10	-.03	-.10
	9*	-1.86	- .19	- .15	-.17	-.08	-.23
	10*	- .66	- .34	- .83	-.04	-.08	-.30
	11*	- .81	.16	- .02	.01	-.06	-.07
	12	3.79	.23	.26	.03	.01	.14
	13	2.88	.30	.50	.11	.02	.28
	14	1.46	- .08	.20	.09	-.03	.00

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* 3 g nitrogen intake.

** "Zero" nitrogen intake.

APPARENT EXTERNAL METABOLIC BALANCES, g/day, BY METABOLIC PERIOD
[Intake - (Fecal + Urinary Excretion)]

Subject	Period	Treat-ment	Nitrogen	Calcium	Sodium	Potassium	Phosphorus	Magnesium
0201	I	A12	.03	-.13	-.32	.09	-.26	-.06
	II	A12	1.17	.12	.03	.35	.02	-.01
	III	A12	- .68	.08	-.41	.07	-.11	-.04
	IV	A12	.62	-.02	-.18	.18	-.08	-.04
	V	A12	.49	-.09	-.08	.16	-.19	-.07
0202	I	A12	-1.06	-.15	-.19	- .07	-.31	.03
	II	A12	- .04	-.21	-.18	.21	-.25	-.05
	III	A12	- .18	-.20	-.23	.13	-.28	-.07
	IV	A12	.18	-.04	-.30	- .10	-.31	-.04
	V	A12	.84	-.08	.01	.27	-.15	-.05
0203	I	A12	- .74	-.01	-.21	- .03	-.20	-.06
	II	A0	-4.08	-.11	-.49	- .80	-.38	.09
	III	A3	-1.01	-.09	-.11	- .18	-.17	-.03
	IV	A3	- .49	-.10	-.05	- .06	-.18	-.04
	V	A12	2.69	-.09	.10	.27	-.05	-.04
0204	I	A12	1.74	-.14	-.46	.28	.00	.05
	II	A3	- .78	.13	-.24	.24	-.03	.00
	III	A12	2.03	-.13	-.40	.17	-.08	-.04
	IV	A0	-2.96	-.03	-.32	-1.01	-.38	-.10
	V	A12	3.93	-.09	.04	.40	.01	-.04
0205	I	A12	.15	-.18	.32	- .31	-.02	.05
	II	A0	-3.90	-.19	-.12	- .19	-.40	-.13
	III	A3	-1.00	-.05	.42	- .25	-.16	-.03
	IV	A3	- .43	-.07	.65	- .18	.04	-.04
	V	A12	4.77	.10	.76	.58	.20	.04
0206	I	A12	1.54	.05	-.33	.26	-.09	.03
	II	A0	-3.36	-.25	-.87	- .53	-.50	-.15
	III	A12	3.30	-.03	-.16	.23	.08	.03
	IV	A3	-1.03	-.07	-.05	- .14	-.14	-.06
	V	A12	2.71	.07	.16	.28	.13	.00

APPARENT EXTERNAL METABOLIC BALANCES
g/day, BY DIET

Diet	Sodium	Potassium	Calcium	Magnesium	Phosphorus
12 g nitrogen/ day (N = 324 man/days)	-.11	.19	-.01	-.02	-.08
3 g nitrogen/ day (N = 108 man/days)	-.08	-.12	-.27	-.04	-.13
"Zero" nitrogen/ day (N = 72 man/days)	-.50	-.63	-.14	-.11	-.44

APPARENT EXTERNAL METABOLIC BALANCES (g/day)

(Intake - (Fecal + Urinary))

	Nitrogen	Potassium	Phosphorus	Calcium	Magnesium	Sodium	Chloride	Water
Gemini intake	15.6	2.8	1.5	0.81	0.23	5.6	7.6	2258
Subject Balances								
0301	0.20	0.11	-0.05	.005	-0.027	0.16	0.02	391
0303	-0.41	-0.12	-0.05	-.008	-0.029	0.59	0.42	815
0304	-1.00	-0.11	-0.11	-.072	-0.038	0.66	0.58	839
0305	-0.82	-0.01	-0.12	-.113	-0.046	0.31	0.10	859
0308	-0.80	-0.09	-0.11	-.072	-0.056	0.66	0.40	961
0312	-0.59	0.03	-0.04	.028	-0.030	0.42	0.22	862
Average	-0.57	-0.03	-0.08	-.039	-0.038	0.47	0.29	788
Formula intake	12.2	3.31	1.32	0.815	0.492	3.44	4.06	2743
Subject Balances								
0302	-0.57	0.01	-0.04	.073	-0.001	0.38	0.24	1366
0306	-1.44	-0.14	-0.08	.037	-0.017	0.50	0.22	1280
0307	0.72	-0.06	0.01	.039	-0.048	0.39	0.09	901
0309	-0.34	-0.20	-0.03	.020	-0.028	0.64	0.42	1075
0310	0.30	0.06	0.00	-.036	-0.054	0.42	0.06	706
0311	-0.40	-0.05	-0.04	.016	-0.041	0.64	0.17	1007
Average	-0.29	-0.06	-0.02	.025	-0.032	0.50	0.20	1056

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APPENDIX I

History, Physical Examination, and Initial Laboratory Findings on Each Subject

<u>0101</u>

37-year old white male. Date of birth: February 26, 1927

Family history: Father died mid-70's of heart attack. Mother in mid-70's in good health. One sister age 34; one brother age 32; living and well.

Subject has resided in United States all his life. He served in the U.S. Army in 1945-46. He has never been married.

Education: M.A. in History; currently working toward Ph.D. degree.

Illnesses: Childhood - measles, chickenpox, whooping cough, mumps. At age 8 subject was on a sugar-free diet for 1 year; it was thought that he had diabetes but diagnosis was incorrect. As an adult has had no infectious illnesses. Surgery: tonsillectomy at age of 3 or 4. Has had no serious accidents.

Systemic review: Subject has worn glasses since age 16 for myopia. He smokes about 1½ packages of cigarettes per day; is an infrequent social drinker; consumes about 10-12 cups of coffee a day. His weight fluctuates very slightly; maximum is about 165 lb, average 155-158 lb.

Physical examination: Subject is asthenic but otherwise well-developed white male; height 74 in, weight 149½ lb; B.P. 110/70; waist 31 in. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 15.0 gm; pack cell volume 43%; white blood count 10,900; differential - segs. 60%, nonsegs 4%; lymphocytes 29%, monocytes 4%; eosinophils 3%. Urinalysis - specific gravity 1.020; pH 6.0; faint trace of albumin; sugar negative; microscopic revealed occasional white cells, otherwise within normal limits; sedimentation rate 13 mm uncorrected, 11 mm corrected. Blood chemistry - fasting blood sugar 85 mg %; blood urea nitrogen 16 mg %; uric acid 4.5 mg %; cholesterol 231 mg %; SGPT 21 Karmen units.

0102

25-year old white male. Date of birth: December 6, 1938

Family history: Father age 71, living and well. Mother died at age 54 of myocardial infarction. Two sisters living and well.

Subject has resided in the United States all his life.

Education: A.B. in History; some graduate work.

Illnesses: Childhood - measles, chickenpox. Only adult infectious illness was infectious mononucleosis in late 1963. Surgery: tonsillectomy 1943; hernia repair 1956. In January 1964 while convalescing from infectious mononucleosis subject was in auto accident; suffered fractures of left hip and femur, concussion, some damage in left knee. Fracture corrected by open reduction with pin in place; subject was walking within 3 weeks without crutches. He also sustained some damage to nerves of left lower lip and injury to ulnar nerve of left arm; since then has had some decreased sensation of left hand area with residual numbness and tingling on occasions. Has had an excellent exercise program so muscle development has remained good. Approximately 2 months after accident he had a few dizzy spells. These persisted for about 2 weeks. When subject consumes excessive alcohol or is particularly tired he still tends to have some return of dizzy spells.
Previous accidents: In high school subject had a chipped cartilage of left knee due to injury in an athletic event.

Systemic review: Subject has worn glasses for myopia since age 9. He has occasional hay fever which appears to be mainly seasonal. Since the accident has occasional discomfort in chest, but this is not severe. He smokes a pipe occasionally. No significant change in weight except for some weight gain with inactivity after automobile accident. The only medication subject uses is occasional bufferin for nasal drip.

Physical examination: Well-developed male; weight 137 lb, height 68 in, waist 28½ in; B. P. 130/80. All findings normal except for a large surgical scar over left lateral thigh and small midline scar on upper chest.

Laboratory work: Blood count - hemoglobin 16.8 gm; pack cell volume 47%; red blood count 5.47 million, white count 7,900; differential - segs 66%, nonsegs 2%, lymphocytes 26%, monocytes 4%, basophils 2%. Urinalysis: specific gravity 1.009; pH 7; albumin and sugar negative; microscopic negative; sedimentation rate 3 mm. Blood chemistry - fasting blood sugar 71 mg %; blood urea nitrogen 12 mg %; uric acid 4.3 mg %; cholesterol 180 mg %; SGPT 16 Karmen units.

0103 - 0204

23-year old white male. Date of birth: April 30, 1941.

Family history: Father age 44, living and well; possible heart attack in 1963. Mother age 43 in good health. No siblings.

Subject has resided in United States all his life.

Education: A.B. in English; graduate work subsequently; now doing creative writing.

Illnesses: Childhood - measles, mumps, chickenpox, whooping cough. Subject has suffered no serious accidents. Surgery: tonsillectomy at age 6. A granuloma about foreign matter was removed from heel of left foot several years ago.

Systemic review: Subject has worn glasses for past 10 years for myopia and astigmatism. He does not smoke; is an infrequent social drinker. Weight has been constant for past four or five years.

Physical examination: Subject is a well-developed white male, height 70½ in, weight 138 lb, B.P. 114/70, waist 27½ in. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 16.0 gm, pack cell volume 46.5%, red count 5.61 million, white count 5,400; differential - polymorphonuclear segs 65%, lymphocytes 19%, monocytes 10%, eosinophils 5%. basophils 1%. Urinalysis - specific gravity 1.023, pH 7.5, albumin and sugar negative, microscopic negative, sedimentation rate 1 mm. Blood chemistry - fasting blood sugar 86 mg %, blood urea nitrogen 17.5 mg %, uric acid 5.5 mg %, cholesterol 164 mg %, SGPT 18 Karmen units.

0104 - 0205

21-year old white male. Date of birth: July 11, 1943.

Family history: Father died age 41, heart attack. Mother age 49, living and well. Two brothers ages 22 and 18 in good health.

Subject has resided in United States all his life.

Education: After high school, extensive reading and acting study in New York.

Illnesses: Subject had polio at age 3. Had slight weakness in back and mild scoliosis; has exercised extensively for this. There are no residuae. Childhood - measles, mumps, chickenpox. He has had no serious accidents except for occasional broken fingers and cartilage tear of left knee while playing football; has occasional stiffness in left knee as result of latter. Surgery: He had two hernia operations (1948 and 1951); about 7 months ago had pilonidal cyst repaired.

Systemic review: Entirely normal except for occasional hay fever. He smokes about 4 cigarettes per day, uses no alcohol. His weight varies between 185 and 200 lb, depending upon amount of exercise.

Physical examination: Well-developed muscular male; height 71-3/4 in, weight 181 lb; B. P. 110/74; waist 32 in. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 13.9 gm; pack cell volume 39.5%; red blood count 4.54 million, white count 7,300; differential - segs 52%, lymphocytes 38%, monocytes 7%, eosinophils 2%, basophils 1%. Urinalysis - specific gravity 1.030; pH 5; albumin, sugar, microscopic all negative; sedimentation rate 5 mm. Blood chemistry - glucose 91 mg %; blood urea nitrogen 17 mg %, uric acid 4.4 mg %, cholesterol 195 mg %, SGPT 21 Karmen units.

0201

25-year old white male. Date of birth: February 24, 1939.

Family history: Father age 64, Mother age 51; living and well. Two brothers age 23 and 21, one sister age 18; all in good health.

Subject has resided in United States all his life except 1 year spent in Germany (1947).

Education: B.A. in English 1963; no formal graduate work.

Illnesses: Childhood - measles, mumps. No serious infections or diseases as an adult. Subject has had no surgery or serious accidents. He was discharged from the Army after 1 year because of "mild anxiety."

Systemic review: Subject has worn glasses for past 10 years for myopia and astigmatism. Teeth are in rather poor condition; he is currently having these repaired. He consumes about 1 package of cigarettes per day. His weight averages 165-175 lb, but has been somewhat less recently.

Physical examination: Subject is a tall, thin white male; height 74½ in, weight 153 lb; B. P. 130/80. Has had extensive repair on many of his teeth; a number are missing, particularly several molars. There is a pigmented area over left upper thigh. Palms and feet are moist; liver is palpable 2 cm below costal margin on deep inspiration.

Laboratory work: Blood count - hemoglobin 17.0 gm; pack cell volume 47% white count 6,800; differential - segs 56%, lymphocytes 29%, monocytes 8%, eosinophils 6%, basophils 0%. Urinalysis - specific gravity 1.027; pH 6; albumin, sugar, microscopic negative. Blood chemistry - fasting blood sugar 62 mg %; blood urea nitrogen 14 mg %; uric acid 5.2 mg %; cholesterol 167 mg %; SGPT 19 Karmen units.

0202

24-year old white male. Date of birth: August 27, 1940.

Family history: Father died age 56 in car accident. Mother age 47 living and well. One sister age 19, 1 half-brother age 38; both in good health.

Subject was born in Germany, residing there most of his life; came to the United States in January 1964.

Education: Subject was student for 3 years at Max Planck Institute; studied nitrition and biochemistry.

Illnesses: Childhood - mumps. No serious infections or illnesses as an adult. Subject had small cut on right hand; no other surgery; no other accidents.

Systemic review: Entirely normal. Subject does not smoke; uses occasional beer. Weight averages about 175 lb.

Physical examination: Well-built white male; height 66-3/4 in, weight 175½ lb; B. P. right arm 130/80, left arm 140/90. All findings entirely normal. Subject has a small scar over right knee; liver was just palpable on deep inspiration.

Laboratory work: Blood count - hemoglobin 14.5 gm; pack cell volume 43%; white count 6,300; differential - segs 75%, nonsegs 1%, lymphocytes 17%, monocytes 5%, eosinophils 2%, basophils 0%. Urinalysis - specific gravity 1.022; pH 6; albumin, sugar, microscopic negative. Blood chemistry - fasting blood sugar 75 mg %; blood urea nitrogen 16 mg %; uric acid 5.2 mg %; cholesterol 214 mg %; SGPT 52 Karmen units.

0203

27-year old white male. Date of birth: October 4, 1937.

Family history: Father age 64, Mother age 67, 1 brother age 39; all in good health.

Subject has resided in United States all his life. He was in six-month program and in inactive reserve for the Air Force.

Education: Approximately 3 years of college - English, Business Administration.

Illnesses: Childhood - measles, mumps. Adult - age 17 hepatitis; etiology not certain but believed to be due to infectious mononucleosis. In 1962 had lingering upper respiratory tract infection which was ended with tonsillectomy in that year. No serious accidents.

Systemic review: Entirely normal. Intermittent moderate to at times heavy use of alcohol; usually has wine with meals. Up to 2 months ago smoked about 12 cigarettes per day; recently about 2 to 3 per day. Weight has remained steady for past 10 years at about 160-170 lb.

Physical examination: Well-built male; height 72½ in, weight 159½ lb; B. P. 130/80. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 16.1 gm; pack cell volume 43%; white count 5,100; differential - segs 57%, nonsegs 1%, lymphocytes 30%, monocytes 7%, eosinophils 4%, basophils 2%. Urinalysis - specific gravity 1.025; pH 6; albumin, sugar, microscopic negative. Blood chemistry - fasting blood sugar 91 mg %; blood urea nitrogen 14.5 mg %; uric acid 5.0 mg %; cholesterol 184 mg %; SGPT 23 Karmen units.

0206

28-year old white male. Date of birth: November 3, 1936.

Family history: Father died age 54 of carcinoma of the lung; was a heavy smoker. Mother age 57 living and well. Three brothers: 1 fraternal twin in good health; 1 brother age 30 who suffered a birth injury; 1 brother age 34 in good health.

Subject has resided in United States all his life.

Education: B.S. In Elementary Education just completed; total college approximately 6½ years.

Illnesses: Childhood - measles, not serious. No serious infections as an adult. Surgery: Hernia repair 1963; appendectomy 1951. Accidents: 1964 fell and hit head; suffered 2 lacerations on scalp; has no neck problems.

Systemic review: Subject had gonerrhea about 2 years ago; treated without sequelae. He has smoked about 1 package of cigarettes a day since age 22. Weight has remained constant at about 130-135 lb.

Physical examination: Subject is a slightly asthenic but otherwise normal male; height 68 in, weight 131½lb; B. P. 130/80. All findings entirely normal except for mild vitiligo.

Laboratory work: Blood count - hemoglobin 16.5 gm; pack cell volume 48.5%; white count 10,700; differential - segs 70%, nonsegs 1%, lymphocytes 23%, monocytes 2%, eosinophils 2%, basophils 2%. Urinalysis: specific gravity 1.006; pH 6; albumin, sugar, microscopic negative. Blood chemistry: fasting blood sugar 74 mg %; blood urea nitrogen 11 mg %; uric acid 4.3 mg %; cholesterol 166 mg %; SGPT 21 Karmen units.

0301

20-year old Oriental male. Date of birth: March 19, 1945.

Family history: Father age 58, Mother age 48, 1 sister age 23, 2 brothers age 17 and 14; all in good health.

Subject has resided in United States all his life.

Education: Bachelor's Degree 1966.

Illnesses: Childhood - measles, mumps, chickenpox. Surgery: Repair of cut right thigh after falling off swing as a child. Accidents: None, except that noted above.

Systemic review: Subject has worn glasses for 3 years because of myopia. He is a nonsmoker. Weight has been quite constant over the past several years.

Physical examination: Subject is a small, Oriental male of normal habitus; height 65 in, weight 124½ lb; B. P. 110/70; pulse 108. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 16.0 gm; pack cell volume 46%; white count 7,600; differential - segs 71%, nonsegs 0%, lymphocytes 23%, monocytes 4%, eosinophils 2%. Urinalysis - specific gravity 1.021; pH 6.0; albumin, sugar, microscopic negative. Blood chemistry - fasting blood sugar 84 mg %; blood urea nitrogen 15 mg %; uric acid 4.4 mg %; cholesterol 174 mg %; SGPT 20 Karmen units. PBI 4.9 mg %, total protein 8.0 g %.

0302

21-year old white male. Date of birth: August 3, 1943.

Family history: Father age 53, Mother age 57, 1 brother age 23, 1 sister age 18; all living and well.

Education: Bachelor's Degree; to report to Naval Officer's Training School in September 1965.

Illnesses: Childhood - chickenpox, measles. Surgery or accidents: None.

Systemic review: Entirely normal. Subject is a nonsmoker and uses almost no alcohol.

Physical examination: Subject is a well-muscled white male; height 67-3/4 in, weight 173½ lb; B. P. 120/80. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 16.2 gm; pack cell volume 47%; white count 7,300; differential - segs 69%, nonsegs 0%, lymphocytes 22%, monocytes 5%, eosinophils 3%, basophils 1%. Urinalysis - specific gravity 1.020; pH 6; albumin, sugar, microscopic negative. Blood chemistry - glucose 3 hours after eating 80 mg %; urea nitrogen 14.5 mg %; uric acid 4.8 mg %; cholesterol 161 mg %; SGPT 29 Karmen units. PBI 4.9 mg %; total protein 6.9 g %.

0303

30-year old Negro male. Date of birth: February 27, 1935.

Subject has resided in United States all his life. From May 1954 to March 1956 he was in military service.

Illnesses: Childhood - measles; pneumonia at age 3. No serious infectious illnesses. Surgery for nasal fracture.

Systemic review: Subject has been a professional boxer; at age 21 suffered ruptured right ear drum which healed; has never been knocked unconscious. He had gonerrhea approximately 2 years ago. One episode of hematuria as a child; not diagnosed. He smokes about one package of cigarettes a week; uses alcohol on occasion, not excessively. Weight has not shown significant variation for the past several years.

Physical examination: Subject is a well-muscled Negro male. Height 71-3/4 in, weight 196¼ lb; B. P. 120/78. There is a small scar over the area of the left forehead; otherwise the physical examination was entirely normal.

Laboratory work: Blood count - hemoglobin 14.4 gm; white count 6,300; differential - segs 49%, nonsegs 0%, lymphocytes 42%, monocytes 7%, eosinophils 1%, basophils 1%. Blood chemistry - uric acid 5.9 mg %, cholesterol 186 mg %; SGPT 40 Karmen units; Triglyceride 120 mg %.

0304

21-year old white male. Date of birth: October 29, 1943.

Family history: Father age 43 living and well; Mother age 49 under treatment for hypertension at present. Two sisters age 14 and 19 in good health.

Subject has resided in United States all his life.

Education: Bachelor's Degree June 1965.

Illnesses: Childhood - virus pneumonia age 10; measles, mumps, chickenpox. Between fall 1964 and February 1965 subject had been having some stomach distress and a small ulcer was discovered on X-ray; subject was symptom free after 3 weeks treatment and has been well without medication since that time. He has never had any surgery or serious accidents.

Systemic review: Subject had occasional mild hay fever in the past. He quit smoking in 1964.

Physical examination: Subject is a normal, well-built blond male; height 72½ in, weight 175-1/4 lb; B. P. 120/72. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 15.4 gm; white count 5,300; differential - segs 48%, nonsegs 0%, lymphocytes 36%, monocytes 7%, eosinophils 9%, basophils 0%. Blood chemistry - uric acid 6.1 mg %; cholesterol 196 mg %; SGPT 21 Karmen units.

0305

20-year old white male. Date of birth: November 3, 1944.

Family history: Father age 48, Mother age 46, 1 brother age 14, 2 sisters age 18 and 10; all in good health.

Subject was born in British Columbia; came to United States at age 2 months.

Education: Subject is currently a Senior at the University.

Illnesses: Childhood - measles, mumps, chickenpox; no other. Surgery: Tonsillectomy age 11; no accidents.

Systemic review: Subject has used reading glasses for the past 4 years. He does not smoke or drink.

Physical examination: Subject is a well-developed white male; height 68 in, weight 150-3/4 lb; B. P. 120/80. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 16.0 gm; pack cell volume 45%; white count 10,300; differential - segs 48%, nonsegs 0%, lymphocytes 45%, monocytes 3%, eosinophils 3%, basophils 1%. Urinalysis - specific gravity 1.024; pH 6.4; albumin, sugar, microscopic negative. Blood chemistry - glucose 88 mg %; urea nitrogen 17.4 mg %; uric acid 4.5 mg %; cholesterol 190 mg %. SGPT 28 Karmen units. PBI 6.0 mg %; total protein 7.0 g %.

0306

21-year old white male. Date of birth: September 28, 1943.

Family history: Father age 53, Mother age 51, 1 brother age 23, 1 sister age 18; all in good health.

Subject has resided in United States all his life.

Education: Subject is currently a Senior at the University.

Illnesses: Childhood - probable measles, possible mumps. No serious illnesses. In 1948 had eye surgery for deviated eye. No serious accidents.

Systemic review: Subject has astigmatism and has worn glasses since age 3. He smokes about half a package of cigarettes per day; he utilizes almost no alcohol. Weight has remained constant for past several years.

Physical examination: Height 71½ in, weight 186½ lb; B. P. 117/76. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 15.6 gm; pack cell volume 43.5%; white count 9,300; differential - segs 61%, nonsegs 6%, lymphocytes 19%, monocytes 11%, eosinophils 2%, basophils 1%. Urinalysis - specific gravity 1.023; pH 6; albumin, sugar, microscopic negative. Blood chemistry - fasting blood sugar 80 mg %; blood urea nitrogen 14 mg %; uric acid 4.9 mg %; cholesterol 46 mg %; SGPT 50 Karmen units. PBI 3.8 mg %; total protein 8.0 g %.

0307

21-year old white male. Date of birth: July 25, 1944.

Family history: Father age 56, Mother age 48, 2 brothers age 25 and 26, 1 sister age 14; all living and well.

Subject has resided in the United States all his life.

Education: Senior Psychology Major at the University.

Illnesses: Childhood - possible mumps. No surgery, no accidents.

Systemic review: Subject has worn glasses for the past 3 years. He does not smoke and uses no alcohol. He has no significant recent weight change.

Physical examination: A slightly asthenic but otherwise normal male; height 69½ in, weight 149-3/4 lb; B. P. 130/80. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 16.3 gm; pack cell volume 46%; white count 7,900; differential - segs 72%, nonsegs 0%, lymphocytes 21%, monocytes 4%, eosinophils 2%, basophils 1%. Urinalysis - specific gravity 1.021; pH 6.0; albumin, sugar, microscopic negative. Blood chemistry - 5½ hr postprandial blood sugar 81 mg %; urea nitrogen 14.5 mg %; uric acid 4.3 mg %; cholesterol 188 mg %; SGPT 26 Karmen units. PBI 5.6 mg %; total protein 7.6 g %.

0308

23-year old white male. Date of birth: November 29, 1941.

Family history: Father age 52 living and well. Mother age 52 in fair health; has had surgery for carcinoma of the breast and suffers from gout. Two brothers age 22 and 17 living and well.

Subject has resided in United States all his life. From November 1960 to October 1963 was in Army as voice intercept operator with service in Germany from February 1961 to October 1963.

Education: Graduated from the University and worked in community health services for the State Health Department.

Illnesses: Childhood - measles and mumps. Adult - scarlet fever at age 20 while in Army; no known sequelae. Surgery - tonsillectomy at age 7 or 8. Accidents - greenstick fracture at age 5 or 6 without sequelae.

Systemic review: Subject faints easily when is giving blood or when receiving shots; has had occasional postnasal drip which has not been severe. He smokes about 1½ packages of cigarettes a day; his alcohol intake is variable but only social. There has been no significant weight change.

Physical examination: Subject is a well-muscled white male; height 71-1/4 in, weight 167 lb; B. P. 120/78. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 16.4 gm; pack cell volume 49%; white count 7,900; differential - segs 57%, nonsegs 0%, lymphocytes 40%, monocytes 8%, eosinophils 1%, basophils 0%. Urinalysis - specific gravity 1.016; pH 6; albumin, sugar, microscopic negative. Blood chemistry - glucose 79 mg %; blood urea nitrogen 11.5 mg %; uric acid 4.4 mg %; cholesterol 158 mg %; SGPT 46 Karmen units. PBI 5.1 mg %; total protein 7.2 g %.

0309

22-year old white male. Date of birth: September 20, 1942.

Family history: Father age 56, Mother age 55 in good health; Father shows some evidence of premature aging. There are no siblings. Father has had some skin cancer.

Subject has resided in the United States all his life. He traveled in 1954 to Australia and Hawaii.

Education: Subject has completed the equivalent of 3 years of University.

Illnesses: Childhood - measles, mumps, chickenpox. Adult - epididymis 4 years ago. He has suffered from asthma with a severe attack at age 14; he continued to have intermittent attacks to age 14½ but has had no difficulty since that time. Subject has had some psychiatric care; was released about 9 weeks ago by his psychiatrist. No surgery; no serious accidents.

Systemic review: Subject wears glasses for reading but can get along without them. He smokes about 1½ packages of cigarettes a day; alcohol intake is variable but never serious. At the time he was first seen he was receiving stelazine, 1 mg 3 times a day, but had been told that he could discontinue this medication and this was ordered and done before he entered the Study.

Physical examination: Well-muscled adult; height; height 71½ in, weight 185¼ lb; B. P. 110/70. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 15.1 gm; pack cell volume 44%; white count 10,200; differential - segs 67%, nonsegs 0%, lymphocytes 23%, monocytes 5%, eosinophils 4%, basophils 1%. Blood chemistry - 2 hr post-prandial glucose 91 mg %; urea nitrogen 14.5 mg %; uric acid 4.4 mg %; cholesterol 190 mg %; SGPT 22 Karmen units. PBI 5.9 mg %; total protein 7.8 g %.

0310

28-year old white male. Date of birth: August 13, 1937.

Family history: Father age 63 living; suffered heart attack 1½ years ago. Mother age 54 in good health. No siblings.

Subject was born in Hungary; resided there until 1956. Traveled to Austria for a few months and then to the United States.

Education: Through 3 years of college.

Illnesses: Childhood - mumps, measles, whooping cough. At age 9 to 10 scarlet fever without sequelae. Chickenpox at age 20. No history of rheumatic fever. No serious accidents. Surgery: tonsillectomy age 7; appendectomy 1949.

Systemic review: Entirely normal. Subject does not smoke; utilizes almost no alcohol.

Physical examination: Subject is a thin, asthenic individual; height 70-3/4 in, weight 144-3/4 lb; B. P. 130/80. Multiple ectopics of apparently ventricular origin were noted which disappeared with exercise. Examination of heart entirely normal and all findings entirely normal. EKG revealed ventricular ectopic beads from one focus which disappeared on exercise; otherwise, EKG was entirely normal.

Laboratory work: Blood count - hemoglobin 16.5 gm; pack cell volume 46.5%; white count 7,000; differential - segs 63%, nonsegs 0%, lymphocytes 32%, monocytes 4%, eosinophils 1%, basophils 0%. Urinalysis - specific gravity 1.024; pH 6.0; albumin, sugar, microscopic negative. Blood chemistry - 3-hour postprandial glucose 80 mg %; urea nitrogen 18.5 mg %; uric acid 5.5 mg %; cholesterol 182 mg %; SGPT 32 Karmen units. PBI 6.6 mg %; total protein 8.0%.

0311

39-year old white male. Date of birth: September 4, 1925.

Family history: Father died age 40; hypertension and stroke. Mother age 67; one sister age 35; both living and well.

Subject has resided in the United States all his life. Between 1950 and 1959 he resided in Europe and Asia in the Diplomatic Corps; military service 1943 to 1946. He has never been married.

Education: Subject is currently in Graduate School working toward completion of his PhD Degree.

Illnesses: Childhood - measles followed by an ear infection which was very severe. Mumps age 27; gonerrhea age 29. Subject received hormone shots for a unilateral undescended testicle which was corrected by this treatment. He has had no surgery, no serious accidents.

Systemic review: Subject states in general he has had no health problems except for borderline hypertension first noted about 1 month previously for which he was advised to lose weight and occasional recurring hemorrhoids protruding with bleeding. He has occasional hay fever which is not too severe. A history of marginal elevation of blood pressure was noted. Weight has gradually increased and is attributed to partially sedentary life.

Physical examination: Subject is a slightly obese, graying white male. Height 72½ in, weight 196 lb; B. P. 130/86; the liver was palpable, nontender, 2 cm below the costal margin; the right testes was quite small; otherwise, physical examination was normal.

Laboratory work: Blood count - hemoglobin 15.5 gm; pack cell volume 45%; white count 5,700; differential - segs 68%, nonsegs 0%, lymphocytes 25%, monocytes 4%, eosinophils 2%, basophils 1%. Urinalysis - specific gravity 1.015; pH 5; albumin, sugar, microscopic negative. Blood chemistry - 3-hour postprandial glucose 82 mg %; urea nitrogen 16 mg %; uric acid 4.8 mg %; cholesterol 176 mg %; SGPT 23 Karmen units. PBI 4.8 mg %; total protein 6.9 g %.

0312

29-year old white male. Date of birth: February 21, 1936. Has one child.

Family history: Father age 54; became ill while prisoner of war in Phillippines during World War II with ulcers, recurring malaria. Mother age 51 in good health. Three half-brothers ages 11 to 3; all in good health. Uncle died of heart attack in his 60's; paternal grandfather developed diabetes at age 76.

Subject has moved about a great deal because his Father was in the Army; has been in Berkeley since 1961. Married age 20, separated age 23, divorced age 26.

Education: Subject is currently a graduate student and teaching assistant.

Illnesses: Usual childhood illnesses. Age 19 developed absess of left foot and "palsy" of left arm secondary to carrying heavy packs. Surgery: tonsillectomy as a child. Accidents: fracture of the left arm as a child.

Systemic review: Subject has no significant complaints; has occasional bouts of rectal itching. He smokes about 1½ packages of cigarettes a day; occasional alcoholic intake only social.

Physical examination: Subject is a well-muscled white male. Height 72½ in, weight 196 lb; B. P. 130/80. All findings entirely normal.

Laboratory work: Blood count - hemoglobin 16.0 gm; pack cell volume 47%; white count 10,700; differential - segs 68%, nonsegs 0%, lymphocytes 22%, monocytes 7%, eosinophils 3%. Urinalysis - specific gravity 1.015; pH 6; albumin, sugar, microscopic negative. Blood chemistry - blood glucose 1-hour postprandial 107 mg %; urea nitrogen 14.0 mg %; uric acid 3.4 mg %; cholesterol 190 mg %; SGPT 30 Karmen units. PBI 5.7 mg %.

APPENDIX II

Results of Psychological Inventories on Each Subject
Penthouse Study #3

0301

This individual's test scores revealed a high commitment to work with people on an immediate and direct level. His scores on intellectual variables are not high with the exception of a very strong esthetic orientation. Scores reveal high impulsivity and observations indicate a higher degree of anxiety and "nervousness" than is found in the tests. This subject was probably "test-wise" on the basis of education and experience.

0302

Inventory results revealed this subject as pragmatic and practical (as opposed to theoretical) in orientation, with moderate interest in scientific fields. His scores show a somewhat rigid or simple view of the world, emotional stability coupled with defensiveness, and high desire to make a good impression.

0303

Personality inventory scores indicated this subject to be one with primary practical interests in the life sciences and in verbal expression. His scores indicate a low degree of intellectual commitment or awareness, some of which may be due to a deprived cultural background. This subject had a moderate to high degree of impulsivity and was emotionally stable. On paper he shows little independence, but his observed behavior revealed adequate autonomy.

0304

This subject was strongly oriented theoretically in the direction of social science. Other scores showed intense desire to be liked and to make a good impression (a desire which, according to observation, he fulfilled successfully), a good deal of emotional stability, and some abstract interests.

0305

Personality inventories showed a strong interest in and commitment to the practical field of medical or life sciences, confirmed by conversation with the subject. Scores on other variables showed a very high degree of independence and desire to make a good impression, a low degree of manifest anxiety and emotional instability, and a medium degree of intellectual orientation.

0306

Psychological inventories showed this subject to be strongly and primarily motivated by needs for verbal expression. His impulsivity and schizoid scores were significantly elevated, and so were his scores on scales dealing with flexibility and independence. He shows strong esthetic orientations, some anxiety, and little theoretical or intellectual interest.

0307

This subject had a strong socially directed intellectual orientation. His test scores showed a very high degree of intellectual and theoretical ability and commitment. He appeared stable emotionally, and in fact revealed himself to be so through observation. Nevertheless, his scores also revealed a good deal of drive and energy, suggesting that he is acceptably achievement-oriented.

0308

This subject had a strong intellectual orientation, loosely clustered in the direction of social interests. His scores on intellectual variables are high with the exception of estheticism; his other scores show independence, energy, and emotional stability. This subject was not popular amongst his peers, but was not strongly disliked either.

0309

Psychological inventories showed this subject to be basically social and verbal in orientation, with a strong intellectual-theoretical motivation. Other scores revealed a high degree of impulsivity and emotional complexity, as well as an elevated schizoid factor. The subject manifested much anxiety not only in his test scores but in his behavior. On a scale which measures desire to give a good impression, this subject scored significantly low, which suggests that his behavior may have been used in the past to gain attention, that it was successful in that respect and that, furthermore, such attention was needful for the subject's well-being.

0310

Psychological inventories showed this man to have a strong intellectual orientation fixed, if at all, in the expressive-verbal direction. Other tests showed him to be emotionally stable, having little or no overt anxiety and a very high degree of emotional and intellectual maturity, the latter characteristic confirmed by observation.

0311

This subject's personality inventories showed a strong social science theoretical orientation, indicating that he is committed to working with and for people (as opposed to data). His scores showed maturity, independence, and a good deal of restraint; these characteristics may also partially be due to the experience of the "test-wise" person.

0312

Personality inventories showed this subject to be strongly motivated theoretically in the social and verbal areas. His highest intellectual characteristic was that of complexity (flexibility). He appeared emotionally stable, with little or no overt anxiety, and appeared as well to possess a good deal of drive. He did not make an effort to present himself in a favorable light, at least while taking tests; empiric observation found him to be one of the most mature subjects in the study and supported his test scores of emotional stability.

APPENDIX III

Partial Descriptions of Some Significant* Scales Abstracted from the Respective Manuals

A. California Personality Inventory (CPI)

Do (Dominance) assesses factors of leadership ability, dominance, persistence, and social initiative. High scorers tend to be seen as aggressive, confident, persistent, and planful; as being persuasive and verbally fluent; as self-reliant and independent; and as having leadership potential and initiative.

Cs (Capacity for status) serves as an index of an individual's capacity for status (not his actual or achieved status). The scale attempts to measure the personal qualities and attributes which underlie and lead to status. High scorers tend to be seen as ambitious, active, forceful, insightful, resourceful, and versatile; as being ascendant and self-seeking; effective in communication; and as having personal scope and breadth of interests.

Sp (Social presence) assesses factors such as poise, spontaneity, and self-confidence in personal and social interaction. High scorers tend to be seen as clever, enthusiastic, imaginative, quick, informal, spontaneous, and talkative; as being active and vigorous; and as having an expressive, ebullient nature.

Sa (Self-acceptance) assesses factors such as sense of personal worth, self-acceptance, and capacity for independent thinking and action. High scorers tend to be seen as intelligent, outspoken, sharp-witted, demanding, aggressive, and self-centered; as being persuasive and verbally fluent; and as possessing self-confidence and self-assurance.

To (Tolerance) identifies persons with permissive, accepting, and non-judgmental social beliefs and attitudes. High scorers tend to be seen as enterprising, informal, quick, tolerant, clear-thinking, and resourceful; as being intellectually able and verbally fluent; and as having broad and varied interests.

Ai (Achievement via independence) identifies those factors of interest and motivation which facilitate achievement in any setting where autonomy and independence are positive behaviors. High scorers tend to be seen as mature, forceful, strong, dominant, demanding, and foresighted; as being independent and self-reliant; and as having superior intellectual ability and judgment.

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*Those scales are considered "significant" from which the subjects as a group deviated from the standardized norm by one or more standard deviations.

Py (Psychological-mindedness) measures the degree to which the individual is interested in, and responsive to, the inner needs, motives, and experiences of others. High scorers tend to be seen as observant, spontaneous, quick, perceptive, talkative, resourceful, and changeable; as being verbally fluent and socially ascendant; and as being rebellious toward rules, restrictions, and constraints.

Fx (Flexibility) indicates the degree of flexibility and adaptability of a person's thinking and social behavior. High scorers tend to be seen as insightful, informal, adventurous, confident, humorous, rebellious, idealistic, assertive, and egoistic; as being sarcastic and cynical; and as highly concerned with personal pleasure and diversion.

B. Minnesota Multiphasic Personality Inventory (MMPI)

The K score is used essentially as a correction factor... If it is to be given any concrete nonstatistical meaning, the K score is to be thought of as a measure of test-taking attitude... A high K score represents defensiveness against psychological weakness, and may indicate a defensiveness that verges upon deliberate distortion in the direction of making a more "normal" appearance. A low K score tends to indicate that a person is, if anything, overly candid and open to self-criticism and the admission of symptoms even though they may be minimal in strength. A low K score can also result from a deliberate attempt to obtain bad scores or to make a bad impression ("plus-getting")...

The Hy (Hysteria) scale measures the degree to which the subject is like patients who have developed conversion-type hysteria symptoms. Such symptoms may be general systemic complaints or more specific complaints such as paralyses, contractures (writer's cramp), gastric or intestinal complaints, or cardiac symptoms. Subjects with high Hy scores are also especially liable to episodic attacks of weakness, fainting or even epileptiform convulsions. Definite symptoms may never appear in a person with a high score, but under stress he is likely to become overtly hysterical and solve the problems confronting him by the development of symptoms. It has been found that this scale fails to identify a small number of very uncomplicated conversion hysterias which may be quite obvious clinically and with a single or very few conversion symptoms.

The hysterical cases are more immature psychologically than any other group. Although their symptoms can often be "miraculously" alleviated by some conversion of faith or by appropriate therapy, there is always the likelihood that the problem will reappear if the stress continues or recurs. As in the case of hypochondriasis, the subject with a high Hy score may have real physical pathology, either as a primary result of concurrent disease, such as diabetes or cancer, or as a secondary result of the long-time presence of the psychological symptoms. For instance, constant fears are a frequent background for the development of demonstrable ulcers of the stomach...

The Psychopathic Deviate (Pd) scale measures the similarity of the subject to a group of persons whose main difficulty lies in their absence of deep emotional response, their inability to profit from experience, and their disregard of social mores. Although sometimes dangerous to themselves or others, these persons are commonly likable and intelligent. Except by the use of an objective instrument of this sort, their trend toward the abnormal is frequently not detected until they are in serious trouble. They may often go on behaving like perfectly normal people for several years between one outbreak and another. Their most frequent digressions from the social mores are lying, stealing, alcohol or drug addiction, and sexual immorality. They may have short periods of true psychopathic excitement or depression following the discovery of a series of their asocial or antisocial deeds. They differ from some criminal types in their inability to profit from experience and in that they seem to commit asocial acts with little thought of possible gain to themselves or of avoiding discovery... Some active professional persons have high Pd scores, but their breaks, if any, are either disregarded by others or effectively concealed.

The Schizophrenia (Sc) scale measures the similarity of the subject's responses to those patients who are characterized by bizarre and unusual thoughts or behavior. There is a splitting of the subjective life of the schizophrenic person from reality so that the observer cannot follow rationally the shifts in mood or behavior.

The Sc scale distriguishes about 60 percent of observed cases diagnosed as schizophrenia... An appreciable number of clinic cases not diagnosed as schizophrenia score high on the scale. These cases are nearly always characterized by complicated symptomatic patterns.

The Hypomania scale (Ma) measures the personality factor characteristic of persons with marked overproductivity in thought and action. The word hypomania refers to a lesser state of mania. Although the real manic patient is the lay person's prototype for the "insane," the hypomanic person seems just slightly off normal. Some of the scale items are mere accentuations of normal responses. A principal difficulty in the development of the scale was the differentiation of clinically hypomanic patients from normal persons who are merely ambitious, vigorous and full of plans.

The hypomanic patient has usually got into trouble because of undertaking too many things. He is active and enthusiastic. Contrary to common expectations he may also be somewhat depressed at times. His activities may interfere with other people through his attempts to reform social practice, his enthusiastic stirring up of projects in which he then may lose interest, or his disregard of social conventions. In the latter connection he may get into trouble with the law...

C. Omnibus Personality Inventory (OPI) - Form D

Thinking Introversion (TI): Persons scoring high on this measure exhibit a liking for reflective thought, particularly of an abstract nature. They express interests in areas such as literature, philosophy, and history. Their thinking tends to be less dominated by objective conditions and generally accepted ideas than that of low scorers...

Theoretical Orientation (TO): This scale assesses the degree of interest in using scientific methods in thinking, including interest in science as such and in scientific activities. High scorers are generally more logical, rational, and critical in their approach to problems than those scoring at the average or below.

Estheticism (Es): High scorers endorse statements indicating diverse interests in artistic matters and activities. The content of the statements extends beyond painting, sculpture, and music and includes interests in literature and dramatics.

Complexity (Co): This measure reflects an experimental orientation rather than a fixed way of viewing and organizing phenomena. High scorers are tolerant of ambiguities and uncertainties, are fond of novel situations and ideas, and are frequently aware of subtle variations in the environment. Most persons very high on this dimension prefer to deal with complexity, as opposed to simplicity, and seem disposed to seek out and to enjoy diversity and ambiguity.

Autonomy (Au): The characteristic measured is composed of nonauthoritarian thinking and a need for independence. High scorers are sufficiently independent of authority, as traditionally imposed through social institutions, that they oppose infringements on the rights of individuals. They tend to be nonjudgmental and realistic...

Impulse Expression (IE): This scale assesses the degree to which one is generally ready to express impulses and to seek gratification either in conscious thought or overt action. The high scorers value sensations, have an active imagination, and their thinking is often dominated by feelings and fantasies...

APPENDIX IV

Frequency of Serving Questionnaire

FREQUENCY OF SERVING QUESTIONNAIRE

In the following questionnaire, you are asked to indicate, for each of several dishes that might be sent on a space exploration mission, the frequency with which you believe you could tolerate eating the item without appreciable loss of appetite for it. This is a somewhat difficult estimate to make in the abstract, so please reflect carefully on each item's value to you and try to answer as realistically as you can. If you can estimate the frequency with which you eat a similar item now, or can estimate your own over-all tendency to avoid repetitive meals, these reference points may help you judge more accurately. Please take your time. Make sure you estimate some frequency for each item, but if you think that some comment on particular conditions that would influence the acceptable rate of repetition is in order, it would help to have this information noted. Thank you.

Item	In Six Consecutive Weeks						
EXAMPLE: Bread	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Plain chocolate bar	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Applesauce	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Clam chowder	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Dry raisins	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Sausage, breakfast-type	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Cinnamon toast	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Eggnog	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Dry apricots	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Chicken with gravy	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Crab newburg	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Sugar-coated corn flakes	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never

continued

Item	In Six Consecutive Weeks						
Parsnips	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Cocoa	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Salmon salad	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Fruitcake	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Malted milk shake	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Bacon	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Canned whole kernel corn	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Peanut butter with crackers	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Beef "jerky" (hard, dry beef)	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Potato salad	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Chocolate pudding	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Tea with sugar	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Apple sauce	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Ice cream	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Mashed potatoes	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
"Metrecal" or similar	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Chicken with vegetables (stew)	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Mashed squash	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Potato soup	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Gingerbread	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never

continued

Item	In Six Consecutive Weeks						
Tuna salad	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Scrambled eggs	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Grape juice	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Hot coffee	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Chocolate brownies (cookies)	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Dry peaches	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Spaghetti with meat sauce	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Codfish cakes	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Grapefruit juice	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Green peas (frozen or canned)	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Butterscotch pudding	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Shrimp cocktail	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Apricot pudding	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Buttered toast	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Iced coffee	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Pineapple juice	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Cheese with crackers	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Beef with vegetables (stew)	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Orange-grapefruit juice	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never
Fresh whole milk	3/day	2/day	1/day	2/week	1/week	1/2 week	Rarely or Never

APPENDIX V

Analytical and Clinical Methods

A. Laboratory Methods Used in the Human Nutrition Research Unit

Calcium:

Analytical Methods for Atomic Absorption Spectrometry (Solid Materials), pg. Ca 2, The Perkin-Elmer Corporation, Norwalk, Conn. (1964).

Catecholamines:

Manual of Fluorometric Clinical Procedures, pg. 13, Turner Instrument Co., Palo Alto, Calif. (1962).

Chlorides:

"Automatic Titrations with Aminico-Cotlove Automatic Chloride Titrator," Cat. No. 4-4420B Instruction No. 751-C, American Instrument Co. (1964).

Cotlove, E., and H. H. Nishi, *Clin. Chem.*, 7: 285 (1961).

Citric Acid:

Methods in Enzymology, Vol. III, Academic Press (1957), pg. 426.

Creatinine and Creatine:

Henry, Richard J., Clinical Chemistry, Harper and Row (1964), pg. 292.

Hydroxyproline:

Prochop, Darwin J., and Sidney Udenfriend, *Anal. Biochem.*, 1: 228 (1960).

Magnesium:

Analytical Methods for Atomic Absorption Spectrometry (Liquid Materials), pg. Ca 6, The Perkin-Elmer Corporation, Norwalk, Conn. (1964).

Nitrogen:

Micro-Kjeldahl modification of Block, Richard J., and Kathryn W. Weiss, Amino Acid Handbook, Charles C. Thomas, Springfield, Ill., pg. 11 (1956), using H_2SO_4 as digestion mixture, selenized Hengar granules as catalyst, and 4 percent H_3BO_3.

Phosphorus:

Colowick, Sidney P., and Nathan O. Kaplan, Methods in Enzymology, Vol. III, Academic Press, Inc., N. Y., pg. 843 (1957).

Potassium:

Analytical Methods for Atomic Absorption Spectrometry (Liquid Materials), pg. Ca 6, The Perkin-Elmer Corporation, Norwalk, Conn. (1964).

Sodium:

Analytical Methods for Atomic Absorption Spectrometry (Liquid Materials), pg. Ca 6, The Perkin-Elmer Corporation, Norwalk, Conn. (1964).

Thiamine:

Consolozio, C. Frank, and Robert E. Johnson, "Biochemical and Dietary Procedures, U. S. Army Medical Research and Nutrition Laboratory Report # 242 (1960).

Urea:

Coulomke, J. J., and L. Faureau, *Clin. Chem.*, 9: 102 (1963).

Uric Acid:

Dermatube-U Kit (Enzymatic, Uricase), Worthington Biochem. Corp. (1965).

Xanthurenic Acid:

Modification of Satoh, Kiyoo, and J. M. Price, *J. Biol. Chem.*, 230: 781 (1958), using Turner fluorometer with primary filter #110-818 (7-60) and secondary filter #110-818 (24-12).

B. Methods Unique to Blood Analyses

Ammonia:

W. Muller-Beissenherz und H. Keller, *Klin Wochenschs*, 43: 43 (1965).

Bilirubin:

Molloy, H. T., and K. A. Evelyn, *J. Biol. Chem.*, 119: 481 (1937).

Cholesterol:

Technicon Auto-Analyzer, Technion Co., Chauncey, N. Y., 1963.

Zlatkis-Zak reaction on isopropanol extract of serum.

Zlatkis, A., B. Zak, and A. J. Boyle, *J. Lab and Clin. Med.*, 41: 486 (1953).

Electrophoresis, Protein:

Cellulose acetate, Ponceau R. stain. Resolved fractions eluted and color determined at 520 mμ in Beckman D. U. Spectrophotometer.

Glucose:

Technicon Auto-Analyzer, Technion Co., Chauncey, N. Y., 1963.

Modification of Hoffman, W. S., *J. Biol. Chem.*, 120: 51 (1937).

Glutamic Pyruvic Transaminase, Serum:

Technicon Auto-Analyzer, Technicon Co., Chauncey, N. Y., 1963.

Unpublished method determination of pyruvate formed from d,l-alanine by use of salicylaldehyde.

Protein, Total Serum:

Weichselbaum, T. E., *Amer. J. Clin. Path.*, 7: 40 (1946).

Protein-Bound Iodine:

Dry Ash Method - Barker, S. B., Standard Methods of Clinical Chemistry, Vol. 3, Academic Press (1961), pg. 167.

Totally automated method - Technicon Auto-Analyzer, Technicon Co., Chauncey, N. Y., 1963.

Uric Acid:

Reduction of phospho-tungstic acid, Technicon method N-13a, Technicon Co., Chauncey, N. Y., 1963.

Urea Nitrogen:

Technicon Auto-Analyzer, Technicon Co., Chauncey, N. Y., 1963.

Modification of Skeggs, L. T., *Amer. J. Clin. Path.*, 28: 311 (1957), using carbamido-diacetyl reaction applied to urea.

C. Gas Measurements

Flatus:

Fisher gas partitioner -- dual column gas chromatograph.

Respiratory:

Hydrogen - Wilkens aerograph detector Model 600-C.

Methane - Carad flame ionization unit.

Oxygen - Beckman paramagnetic oxygen analyzer

Carbon Dioxide - Pulmo analyzer -- Thermal analyzer (Godart, Holland)

D. Miscellaneous

Circulating Blood Volume:

Method for Evans Blue -- Warner-Chilcott Division, Morris Plaines, N. J.

-- Henry, R. J., Clinical Chemistry Principles and Techniques, Harper and Row (1964), pp. 899-902.

Total Body Water:

Boling, E. H., *Annals N. Y. Acad. Sci.*, 110: 246 (1963).

Body Composition:

Keys, Ancel, and J. Brozek, "Body Fat in Adult Man," *Physiol. Rev.*, 33: 245 (1953).

Behnke, R. N., "Anthropometric Evaluation of Body Composition Throughout Life," *Annals N. Y. Acad. Sci.*, Part 2: 450 (1963).