STAT

Declassified in Part - Sanitized Copy Approved for Release @ 50-Yr 2014/02/19 :
CIA-RDP81-01043R003700220001-2

[redacted]

THE PHYSIOLOGICAL BASIS FOR VARIOUS CONSTITUENTS IN SURVIVAL RATIONS

Part I. The Efficiency of Young Men Under Temperate Conditions

[redacted]

JUNE 1954

WRIGHT AIR DEVELOPMENT CENTER

[redacted]

STAT

STAT

THE PHYSIOLOGICAL BASIS FOR VARIOUS CONSTITUENTS IN SURVIVAL RATIONS

Part I. The Efficiency of Young Men Under Temperate Conditions

STAT

[redacted]

STAT

June 1954

STAT

[redacted]

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

[redacted]

STAT

STAT

1. In order to arrive at conclusive judgements on the problem of all-purpose, all-environment survival rations, comprehensive studies, combining physiological, biochemical, nutritional, and clinical approaches, must be conducted in the field and in hospitals with emphasis on the effects of physical work, weather, and injury on the body efficiency and organ function of the survivor.

2. According to the results of the present study, the all-purpose survival ration should be planned to provide:

   a. A caloric intake approximating 2000 per day, and more if possible. (The potentially deleterious effects of the regimens studied decreased in the order: starvation, 1000 Calories, 2000 Calories, and 3000 Calories.)

   b. A distribution of calories approximating 15% protein, 52% carbohydrate, and 33% fat. (The greater the deviation from this distribution, the more deleterious the nutrient combination tended to become.)

3. The castaway should be provided with water in amounts as liberal as feasible. (Limitation of water to 900 ml/day was always deleterious regardless of the nutrient mixture.)

4. On the basis of previous military and civilian work, the castaway should be provided with adequate amounts of all known vitamins. (In the present study luxus amounts of vitamins were provided in all experimental mixtures and at all times.)

5. If they are to be incorporated in survival rations, certain present components should be improved technologically in order to obviate certain undesirable clinical symptoms and signs which they produced. (Especially when water was limited, the chocolate bar, meat bar, and cereal biscuit, in that order, frequently evoked gastrointestinal symptoms. The candy components often evoked symptoms in the mouth.)

TABLE OF CONTENTS
(Each Section Is Preceded by a Detailed Table of Contents)

TABLE OF CONTENTS (cont.)

LIST OF FIGURES

STAT

STAT

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

STAT

STAT

LIST OF TABLES

LIST OF TABLES (cont.)

STAT

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

STAT
STAT

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

STAT
STAT

LIST OF TABLES (cont.)

LIST OF TABLES (cont.)

STAT

STAT

LIST OF TABLES (cont.)

SECTION I

GENERAL INTRODUCTION

This one year study was designed as a contribution to the problem of the all-purpose, all-environment survival ration. Within the experimental conditions specified by the contract, it was proposed that a comprehensive study would be made of young men subsisting on a variety of nutrient combinations under temperate conditions and with only moderate physical activity, in order to provide systematic, complete, statistically valid information on bodily efficiency and organ function. Such a study would permit subsequent judgements to be made on the relative merits of a variety of nutrient combinations in sustaining maximally the "survival potential" (Kline and Dyme, 1953) of castaways forced to survive, escape, and evade under any circumstances of environment and physical exertion.

In the initial planning of the present study, and based on the published literature concerning survival rations, it was thought that the overriding considerations could be water intake, total calorie intake, and the ratios of protein, carbohydrate and fat. At first, the importance of inorganic metabolites was minimized; as the study progressed, the possible physiological role of these elements in the maintenance of organ function and bodily efficiency became apparent. Hence, the present report will emphasize four, not three major variables.

In this study, which was conducted in a metabolic ward in a university hospital, it was not even initially proposed to examine three other variables which are fundamental in thinking about survival situations -- work, weather, and injury. These variables should be studied comprehensively in the future, when the present base-line data can be given their true evaluation as a part of a much larger, more complex picture than we were able to study.

Previous investigators in this area have overemphasized primarily one or another limited aspect of the survival problem. They have stressed, for the most part, aspects such as acceptability, palatability, field utility, stability of components, nutrient balance, especially with respect to nitrogen, and minimal water requirements without much regard to the efficiency of the body as a whole and with almost no systematic attention to the normal functions of the major body organ systems. Unfortunately, budgetary restrictions and lack of space and personnel have necessitated for most observers a less than satisfactory statistical design for their experiments. The major criticism which can be levelled at most previous studies on this question, both in the laboratory and

STAT

in the field, are failure comprehensively to study the multiple nutritional interrelations which must be considered in any survival ration; viz., degree of water deficit, amount of calorie deficit, and varying ratios of protein, carbohydrate, and fat in the survival ration. Consequently, the major defects lie usually in lack of adequate paired controls; in lack of adequate range of water deficit, calorie deficit, and nutrient combinations; and (as in the present study) inadequate consideration of stress, weather, exercise, and injury, together with the basic nutritional variables.

Recent sources of information on the survival problem are two: military evidence from field experience, field tests, field experiments and laboratory experiments; and civilian evidence from the literature of explorers; clinical investigation especially during and after World War II in malnourished populations and in concentration camps, and laboratory investigations specifically designed to study one or another aspect of chronic and acute malnutrition.

Because of the exigencies of military campaigns in the first half of the twentieth century, most of the emphasis on survival rations has centered about the problem of military personnel isolated in the performance of active duty. From time to time during this period, emphasis has shifted drastically among three major considerations; i.e., the logistic (field utility, stability, caloric density); the nutritional biochemical (vitamins, nitrogen balance); and what might be termed the clinical (maximal efficiency, adequate calories and water). At the present time it might appear that we are in a phase of overemphasis on the logistic and nutritional biochemical aspects of survival rations and relative underemphasis on the total efficiency and organ function of the castaway himself.

In spite of the fact that much of the written literature has dealt with the military problem, it is emphasized here that there is a very important civilian problem. In times of national emergency it may become necessary that large segments of our population, especially urban, will have to be provided with minimal subsistence after usual avenues of transportation have broken down. Selected groups of civilians may be engaged in guerilla warfare. In peace time, small groups of explorers always face the problem of survival. Under all these conditions, it is certain that the concepts of the military survival ration will apply to the civilians.

The present study had two major aims. The first was to extend previous knowledge of survival rations by a systematic survey of the effects on human subjects of the possible combinations of water intake, calorie intake, and nitrogen/carbohydrate/fat ratios in potential survival rations, the emphasis being principally on efficiency of the body as a whole and the functioning of important organ systems. In other words, our emphasis was on the health and welfare of the castaway himself, in addition to orthodox

biochemical and nutritional interpretations of intakes, balances and composition of blood and excreta. Secondly, the data obtained from these normal young men under temperate conditions, exposed to no vicissitudes of undue stress of weather or injury, would serve as control data for interpretation of studies to be made subsequently on airmen in the various conditions of extreme heat and cold and intermittent periods of exposure to simulation of escape and evasion functions of water and ration requirements. As a by-product, it was planned to obtain as much information as possible concerning the other important problems, viz., rehabilitation of the reached castaway and nutritional merits of the 4-in-1 ration when used for periods of weeks and months.

In establishing the experimental design, we tried to compromise the ideal protocol with existing conditions of control, facilities, and personnel, and at the same time draw statistically valid conclusions for a wide variety of dietary, biochemical, physiological and clinical phenomena. The use of controls were arranged in the following designs. One subject was his own control in that he was always subsisted on one workman's adequate ration, then for two periods on the experimental nutrient combination; and finally for one week on a liberal rehabilitation ration in which food and water were unrestricted in quantity. A second kind of control was that of paired control. For every subject for whom water intake was limited, there was simultaneously another subject subsisting on the same nutrient combination, but with unrestricted water. A third concept of control was introduced by subjecting at one time or another every subject to a period of starvation, in which presumably survival is least promoted and also to a period of two weeks on a 3000 calorie diet adequate in all known nutrients. This latter was considered to promote optimally "survival potential," and the data bore out the validity of our concept of "positive control" and "negative control."

In the course of the work, all combinations were studied of: caloric intake at 3000, 2000, 1000 and 0 per day; water intake of 4000 ml per day and restricted in quantity; and distribution ratios of calories provided from protein, carbohydrate, and fat ranging from very low to very high with respect to each. Thus, 20 nutrient combinations were tested. A total number of subjects were under constant observation for experiments in the research unit at the Malay Intensity Hospital at the University of Illinois. Large numbers of nutrient balance determinations, tests of organ function, clinical observations and physical examinations of blood and excreta were made at regular intervals. The details of all our methods are presented in the next section of this report (Section II).

We undertook an attempt to study and compare existing survival rations. Rather, we tried to establish the underlying physiological and clinical bases which one could use to build the best and most acceptable ration for survivors.

STAT
STAT

SECTION II

METHODS: TABLE OF CONTENTS

A. THE SUBJECTS

1. Selection of Subjects

The most critical aspect of any metabolic study is the proper selection of volunteer subjects. The volunteers must be in good health, psychologically well-oriented, and intelligent. These requirements must be fulfilled as closely as possible so that the subjects can be expected to withstand the stress of prolonged subsistence on monotonous and strange diets under rigidly controlled and extremely restricted conditions. With these objectives in mind the investigators interviewed a number of volunteers. The objectives of the experiment were explained together with the probable restrictions, duties, and bodily reactions. If the candidate appeared to be the type of individual sought, he was given a thorough physical examination by a physician and an E.K.G., chest plate, resting metabolic rate, urinalysis, and complete hematology were done. If the history, physical examination, and laboratory tests failed to reveal any physical or psychological abnormalities which might be aggravated by the stress of the investigation, the individual was accepted as a subject for the experiment. From the large group of volunteers interviewed and examined, twelve young men were chosen. Vital statistical data on these men are given in Table II. 1.

TABLE II. 1

SOME CHARACTERISTICS OF THE TWELVE MALE VOLUNTEER SUBJECTS

Subject No.	Age yr	Height in	Initial Weight lb	Color	Religion
1	21	68	152	Negro	Protestant
2	23	68	156	White	Hebrew
3	25	71	185	White	Protestant
4	25	73	182	White	Catholic
5	22	69	144	White	Hebrew
6	20	67	143	White	Hebrew
7	26	71	147	White	Protestant
8	22	70	146	White	Protestant
9	25	68	151	White	Protestant
10	24	64	160	White	Hebrew
11	27	69	144	White	Catholic
12	24	72	161	White	Hebrew

In Appendix IV are given the complete case histories of each of these twelve volunteers together with the results of the

preliminary laboratory examinations.

Throughout this report the subjects will be identified by number only.

2. Handling of Subjects

Indoctrination: The twelve volunteer subjects were fully informed of all the details into the philosophy of the experiment, the restrictions to which they were to be subjected upon them, and the duties they would be expected to perform regularly throughout the course of the study. Each man was given a formal dissertation of the study together with a detailed outline of the duties and restrictions. This was supplemented by an informal "question and answer" period during which time each man reported the volunteer was to submit to all the restrictions, privations, and duties involved in the experiment and that he was fully prepared to do so. A total of seven weeks was allowed for the final study. At the end of this time each man was given the choice of withdrawing from the study or continuing with the experiment. He was told that he could withdraw at any time without prejudice. All the duties in which their assistance was required were explained.

Division of Duties. The subjects were given responsibilities which they were expected to fulfill promptly. Their participation in performing these duties faithfully greatly facilitated the collection of the necessary data. The following list details the several responsibilities:

Routine Duties

1. You will weigh yourself daily before breakfast and record your weight on the appropriate chart in the examining room. All weights must be made while clothed only in socks and underdrawers.

2. You will empty your bladder daily between 0600 and 0700 and note the exact time on your previous 24-hour urinary specimen bottle and your new urinary specimen bottle.

3. You will take your oral temperature twice daily (before breakfast and at 1600) and record the result on the appropriate chart in the examining room. Do not withdraw the thermometer during the 2-minute period prior to removing your oral temperature. Keep the thermometer in place these 2 minutes or until no further rise is observed.

4. You will have two carmine tablets every Monday at breakfast. These will be placed only in bottles which will be provided. The carmine will serve as the indicator of the 7-day periods of collection.

STAT
STAT

When the carmine first appears, you will discard the marked specimen. Thereafter, you will place all stool specimens in the bottle provided. After the second carmine marker has appeared, you will begin a new bottle. This bottle will be used until the third carmine marker has appeared. The above process will be repeated regularly until the end of the experiments. The dates placed on the stool specimen bottles will be the dates on which the carmine capsules were taken.

5. You will report to McKinley Hospital daily at 0700 for clinical examination and venipuncture. These procedures will be conducted in the examining room.

6. You will report promptly for appointments for special tests.

7. You will maintain a daily diary of your activities stating (1) the nature of the work engaged in and (2) the duration of the work to the nearest 15 minutes. In this diary you will also record each day the number of times each day you pass a stool.

8. You will keep a record of your symptoms and attitudes in your diary.

9. You will be given a pedometer which you should wear as directed at all times. Record in your diary the mileage covered each day.

10. You will record volume of all liquids consumed other than at meal times. These volumes will be reported to the dietitian daily at breakfast.

Restrictions Placed upon the Subjects. The limitations imposed upon the volunteers were those typical of any nutritional-metabolic investigation. The subjects were fully on their honor to abide by these restrictions. Under the conditions of the present study it would have been impossible to exert any police control over them and certainly continuous confinement to the metabolic ward at McKinley Hospital was out of the question.

Routine Restrictions

1. You will eat only the food provided for you at the McKinley Hospital.

2. You will measure exactly (to nearest ml) all liquids consumed between meals and in the evening. Liquids given you at regular meal times will have been measured.

3. Liquids permitted between meals and in the evening include only water and coffee and tea without cream or sugar. No beer, wine, or other alcoholic drinks, soft drinks, sodas, milk shakes, fruit juice, and so on are allowed.

4. All urine will be collected in special bottles which will be provided. Use of toilet facilities is strictly out of bounds. Use only the bottles provided.

5. You will [illegible] hours for [illegible] and work. You will retire, if possible, not later than midnight.

6. The following areas in McKinley Hospital are strictly off-limits:
   a. The chemistry laboratory
   b. The diet kitchen
   c. The staff office

7. Insofar as possible [illegible] with the project director will be at meal times, by appointment, or at morning rounds.

8. Do not discuss any question personal of the test-team about the results of tests (the chemical analyses). The project director is responsible for your well-being and will be glad to discuss the course of the experiments with you when he thinks that such information should be disclosed.

9. You may take showers daily.

10. You may have your hair cut when desired.

11. You may brush your teeth but you must not swallow the rinse water.

12. You may rinse your mouth during periods on limited water but you must not swallow this water unless it has been measured.

13. You will have no contact within visiting [illegible] with other project [illegible] such situations as [illegible] with [illegible] in accordance with the chemical tests with which you [illegible] urine and blood.

14. You will not give blood or urinary specimens to local physicians or blood banks or use the same in laboratory exercises without first consulting the project director.

STAT

The subjects were told that, once the experiment had begun, they would be given no time off unless a serious emergency arose. They were not given freedom from the experimental regimen during the mid-semester recess, spring vacation, and other academic or national holidays which came during the five months' period of study.

Administrative and Experimental Control. Even though the subjects were on their honor to live within the limitations imposed upon them during the course of this investigation, the test director had at his disposal several disciplinary measures if occasion arose for their use. The subjects were paid a substantial wage for participating in the experiment. For infringements of responsibilities and duties, he could fine them -- and on occasion such fines had to be invoked. For serious breach of contract, such as cheating and serious infraction of responsibility, the guilty subject could be fired from the project and even subjected to disciplinary action by the authorities of the University. The more serious action fortunately did not have to be used.

If cheating were suspected, there was available a variety of clinical and biochemical checks which would clearly indicate noncompliance with the experimental conditions. The main check was whether or not such a subject deviated widely in his biochemical response to a given nutrient mixture in comparison to a non-suspected subject. In general, no subject was found to be cheating by any firmly established criteria such as 24-hour creatinine excretion, fasting blood sugar level, ketonuria, 24-hour excretion of chloride, etc. One subject was accused of cheating by his fellow-subjects. This episode, which turned out to be a "scapegoat" phenomenon, is discussed in detail under the part of Section V dealing with psychological reactions.

Obligations to Subjects. Although the volunteers were expected to live under the experimental conditions continuously, it was realized that emergencies might arise which required them to leave the University Campus. When such situations arose, the subjects were accommodated as far as possible without serious loss of experimental continuity. Only two situations arose wherein it was impossible to continue the regimen for a few days, both occurring during recovery periods.

The phasing of the periods when the subjects were subsisting on experimental nutrient mixtures was a compromise between the desires of the USAF and the academic schedule. Fourteen days was selected for reasons listed below. The subjects were expected to continue on the regimen for this period unless their symptoms became so intolerable as to interfere with their regular academic work or to jeopardize their health. If, in the opinion of the project director, either situation developed, the subject was

removed from the experimental regimen promptly and started on the recovery diet. This [illegible] with these subjects promoted greater confidence and also occasioned more penetrating and detailed introspection.

If, during the course of the study, certain illness developed -- whether or not it was considered attributable to the experimental regimen -- the subjects were placed under the care of one of two local physicians [illegible] all of the subjects the usual experimental protocol. In spite of the [illegible] of infectious diseases on the campus, the subjects [illegible] of [illegible] diseases. The subject [illegible] models [illegible] for [illegible] fatalities [illegible] to discuss in detail in the [illegible]. A number of [illegible] upon development but were readily controlled with appropriate therapy.

The interest of the subjects was great and they usually wanted to adapt to the [illegible] as [illegible]. Occasionally their conditions required [illegible] programmes, which resulted in cutting classes or [illegible]. In [illegible] examination, the University Administration [illegible] and [illegible] extending [illegible] so that [illegible] the subject's academic record was not marred.

B. PROTOCOL OF COMPLETE STUDY

The present investigation was one which was conducted on volunteer students who were expected to maintain their classroom appointments and academic responsibilities with as little interruption as possible. Within this framework, the tests which were to be used had to be planned and scheduled. Since one of the primary objectives was to assess as completely as possible the functions of the body as a whole and of the important organs and systems, clinical and biochemical functional tests had to be employed. Most of these tests were very time-consuming. The procedures chosen had to be adapted to the conditions of the study and scheduled so as not to interfere with the subjects' academic program.

Another important consideration in the selection of tests was the health of the subject. Many clinical procedures are associated with side reactions or at least potential side reactions. For health, and safety reasons, only those tests which were innocuous or which had the least potential hazard could be employed. Furthermore, University regulations made it impossible to use certain tests which would have been very informative. All procedures involving radioactive tracers had to be eliminated. Non-radioactive isotopes, however, could be administered to the subjects.

Although these limitations precluded use of certain valuable

and more recent procedures; e.g., bromsulfalein test, exogenous renal function tests involving catheterization, and blood volume determination with radioactive phosphorus, a potentially informative battery was set up. These tests are listed in Table II. 2. The several procedures will be discussed in detail in sections which follow.

1. Groups of Subjects

On the basis of data collected during the "dry-run", the subjects were divided into three groups of four men each. The men in Groups I and II were designated as regular subjects; those in Group III as alternate subjects. Within Groups I and II the subjects were paired. An attempt was made to pair the men on more than morphological grounds but such was not possible. The final pairing was made on the basis of age, height, and weight. It turned out later that this pairing did tend to correlate with biochemical and functional data. The trends became more evident as the data accumulated. The members of Group III were not paired.

2. Periods and Phases of the Investigation

There were three periods in the study: the pre-period, the experimental period, and the recovery period. The pre-period was seven days long, it regularly began on Monday morning with breakfast and it regularly ended the following Monday morning after weighing-in, voiding, and venipuncture. The experimental period was 14 days long and divided into two periods of seven days each. These periods, in theory, extended from Monday to Monday as described above, but, in practice, it was not always possible for the subjects to endure the experimental regimen for the full time. They then had to be placed on the recovery regimen before the 14 days had passed. When this occasion arose the recovery period was that much longer than seven days. This arrangement was followed so that the subjects in the same group would not get out of phase with each other. In theory, then, the recovery period was seven days long and extended from Monday to Monday as in the case of the pre-period.

The investigation was divided into five phases, each phase consisting of a pre-period, an experimental period, and a recovery period. The phases for the two groups were so timed that Group I was always two weeks ahead of Group II. This arrangement was dictated by the fact that only four subjects could be housed on the metabolic ward at one time. Thus, during the experimental periods the subjects lived on the metabolic ward, during the pre- and recovery periods they lived outside of the hospital and reported in for all meals and tests. Under these conditions it was possible to maintain a close contact with the subjects at a time when they might have clinical difficulties requiring prompt attention. In order to establish the two-week differential

OBSERVATIONS-SURVIVAL RATION STUDY

CLINICAL	DIETETIC	METABOLIC BALANCE	BODY COMPOSITION	CLINICAL PATHOLOGY
A Physical Exam B Histories C Cardiovascular 1 B.P 2 Pulse 3 Circulation time 4 Exercise 5 EKG D Neurological	A Intake 1 Grass 2 Weighback B Menus 1 Planning 2 Acceptability 3 Psychological	A Energy B Water C Nitrogen D Na,Ca,K E Cl,P F Acid-Base G Fat Absorption	A Weight B Fat, LBM C Water D Anthropms 2 ECG 3 Tapeuplate D Photographs E Albright Calculations	A Hematology B Urinalysis C Fecal Studies D Blood Chemistry E Urine Chemistry F Blood Enzymes

LIVER FUNCTION	ENDOCRINES	NERVOUS SYSTEM	KIDNEY FUNCTION	GI FUNCTION
A Cholinesterase B Cephalin Floc. C Urobilinogen D Cholesterol E Blood Sugar F Bilirubin	A 17-KS B Eosinophils C Resting MR D Blood Sugar E Serum Na,K,Ca,P F Cholesterol G Water Diuresis H Blood Adrenalin Blood Enzymes	A Control 1 EEG 2 Pupillary time 3 Reaction time B Autonomic 1 Pupil size 2 Blood adrenaline 3 ENG, BP, T C Psyche 1 Physiological time 2 Psychological 3 Diary 4 Progress notes	A Urinalysis B Addis Count C Creatinine Clearance D Ammonia E Osmotic Clearance F Blood Urea G Urine Concentration and Dilution	A Fecal Weight B Fecal Fat C Occult Blood D Formed Elements E Clinical

TABLE II. 2

STAT
STAT

between the groups, the first pre-period for each group was 14 days in duration. The dates of the five phases and their three periods are listed in Table II. 3.

TABLE II. 3

TIME TABLE OF STUDY

Experimental Phases	Days	Group I	Group II	Regimen
	14	Jan. 5 - Jan. 18	Jan. 19 - Feb. 1	Pre-Period
I	14	Jan. 19 - Feb. 1	Feb. 2 - Feb. 15	Experimental
	7	Feb. 2 - Feb. 8	Feb. 16 - Feb. 22	Recovery
	7	Feb. 9 - Feb. 15	Feb. 23 - Mar. 1	Pre-Period
II	14	Feb. 16 - Mar. 1	Mar. 2 - Mar. 15	Experimental
	7	Mar. 2 - Mar. 8	Mar. 16 - Mar. 22	Recovery
	7	Mar. 9 - Mar. 15	Mar. 23 - Mar. 29	Pre-Period
III	14	Mar. 16 - Mar. 29	Mar. 30 - Apr. 12	Experimental
	7	Mar. 30 - Apr. 5	Apr. 13 - Apr. 19	Recovery
	7	Apr. 6 - Apr. 12	Apr. 20 - Apr. 26	Pre-Period
IV	14	Apr. 13 - Apr. 26	Apr. 27 - May 10	Experimental
	7	Apr. 27 - May 3	May 11 - May 17	Recovery
	7	May 4 - May 10	May 18 - May 24	Pre-Period
V	14	May 11 - May 24	May 25 - June 7	Experimental
	7	May 25 - May 31	June 8 - June 14	Recovery

3. Scheduling of Tests

After the experience of the "dry-run," it was possible to decide about how long many of the functional procedures would take to complete. For the sake of convenience principally, the time table or testing protocol (Figure II. 1) was set up on a seven-day basis. Within this frame, the various procedures were distributed in such a way as to yield the most information at what were expected to be the critical stages of each period. To apply the testing protocol to any given phase, let the pre-period begin on the eighth day, the experimental period on the first day, and the recovery period on the first day. The longer pre-period of Phase I can be thought of as consisting of a recovery period -- actually an adjustment period -- and a pre-period proper.

The details of the tests will be described in sections which follow. Suffice it to say at this point that the longer procedures were usually conducted over week-ends when both the subjects and the graduate research assistants were likely to have sufficient time available; e.g., space determinations with sodium thiosulfate, antipyrine, and deuterium oxide; psychological and psychomotor tests; and physical examinations.

TESTING PROTOCOL FOR TYPICAL TWO-WEEK PERIOD

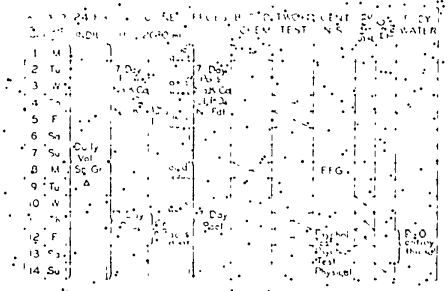

FIGURE II. 1. TESTING PROTOCOL FOR TYPICAL TWO-WEEK PERIOD.

If a subject had to be taken off a given experimental regimen before the complete cycle of tests had been completed, an attempt was made to obtain as much data as possible without compromising the health and cooperation of the subject. In such case the following procedure was followed as closely as possible:

Special Protocol for Early Termination of Experimental Period

1. Immediately notify test director.
2. Fail 24-hour period if possible, and then close current urinary pooled specimen and begin new pooled specimens and the following "on-day" morning. Carefully date these specimens.
3. Draw fasting blood for those substances which will give the most information in the particular case.
4. Perform water tolerance test.
5. Perform organic function-resting metabolism tests.

STAT
STAT

6. If possible, perform exercise-stress test or make space [illegible] examinations, whichever was regularly scheduled for the particular experimental period.

4. The Diurnal Cycle

Many physiological functions and the levels of numerous substances in the blood and urine vary in a diurnal fashion (Kleitman, 19[illegible]). Because it was impossible to test all the subjects simultaneously when any given procedure was conducted, it was necessary to schedule the testing of a given subject in such a way as to eliminate the variability which might be introduced as a diurnal cycle. Therefore, according to the program of each subject, a regular time was established for carrying out all the functional tests. Each subject was tested at the same time of day throughout the period of the investigation. Deviations from this schedule occurred only when the subjects had to be removed from the experimental [illegible] or when the subjects had special academic conflicts, such as final examinations or field trips, neither of which could be planned for weeks in advance.

5. Order of Subsistence on Experimental Nutrient Mixtures

The order in which the subjects subsisted on the several experimental nutrient mixtures could not be completely randomized. It was anticipated that the low caloric regimens would weaken the men, and if they were facing final examinations it would be probable that they would be unwilling to make a serious attempt to complete the full experimental period. In order to achieve the highest cooperation, the order of the experimental diets was in part planned around the academic calendar. Starvation was dated to occur just after completion of the mid-semester final examinations. The 1000-Caloric regimens were placed in the second semester period, and both groups were placed on what were thought might be the least debilitating diet just before (Group I) and during (Group II) the second semester final examinations.

Another consideration was possible seasonal variations. Many of the blood minerals (Sargent, 1951; Josephson and Dahlberg, 1952), the formed elements of the blood (Josephson and Dahlberg, 1952), the functions of such as organs and systems as the autonomic nervous system (Sargent, 1943c) and the kidney (Pitesky and Last, 1951) have been shown to fluctuate seasonally. It was expected that the biochemical and functional changes might be small and so in order to provide for control against seasonal changes, the positive control regimen (3000 Cal/day of 5-in-1 ration) was distributed throughout the five-month period of study: Phases I, III, and V.

Other considerations in detailing the content of the five phases were: (1) No subject was to be given the same nutrient

mixture at the different caloric levels. (2) To avoid possible adaptation, the caloric intakes of the experimental periods were varied among 1000, 2000, and 3000 Cal. per day. Due to an error [illegible] dietaries, subjects 5 and 6 [illegible] on three con[illegible] low-caloric periods. The error actually was useful for [illegible] it allowed [illegible] adaptation. (3) Subject 1 [illegible] such an intolerance [illegible] "hy-[illegible]" that he was not placed in a [illegible]. The final order of subsistence [illegible] investigation is shown in Table [illegible].

6. [illegible] from the Point of View of the Field Trial

As [illegible] field tests to be [illegible] field were available at the [illegible] tests in view. In [illegible] field trial. If [illegible] field laboratory [illegible] control data would be available with which to interpret the results of similar tests conducted on men subsisting on similar nutrient mixtures [illegible] living under more realistic survival conditions.

C. [illegible] AND DIETETIC METHODS

1. Nutrient Mixtures

Two nutritional problems had to be solved in setting up the protocol for this investigation; (1) the choice of the control diet and (2) the choice of foods from which to prepare the nutrient mixtures to be studied. Since it was contemplated that field trials would subsequently be conducted in which the subjects would subsist on similar mixtures, the choice fell to foods which required a minimum of preparation and which were known to have a reasonably high acceptability. Furthermore, since it was desired to use standard food tables for [illegible] the proximate composition of the nutrient intake, items were selected for which [illegible] was already available [illegible] analytical data. For these reasons it was decided that the 5-in-1 ration would be used as the basic diet of [illegible], the [illegible] periods in which the men [illegible] 3000 Cal/day, and the recovery periods. The other nutrient mixtures would be made up from [illegible] components already in use in survival rations; e.g., the sugar [illegible] of the SF-2 [illegible], the AF-2 ration and the Ration, Special Survival; and the cereal biscuit of the Ration, Special Survival.

STAT

Declassified in Part - Sanitized Copy Approved for Release @ 50-Yr 2014/02/19 : CIA-RDP81-01043R003700220001-2

TABLE II. 4

ORDER OF SUBSISTENCE ON
EXPERIMENTAL NUTRIENT MIXTURES

Experimental Phases	Subjects							
	Group I				Group II			
	1	2	3	4-1/2	5	6	7	8
I	N	N	D-2	D-2	ST.	ST.	ST.	ST.
II	ST.	ST.	ST.	ST.	A-1	A-1	B-1	B-1
III	B-2	B-2	N	N	C-1	C-1	N	N
IV	D-1	D-1	C-2	C-2	D-1	D-1	A-1	A-1
V	A-2	A-2	A-2	A-2	N	N	D-2	D-2

Key (See Table II. 5 for description of mixtures):

(1) Underlined symbols indicated limited water intake. (900 ml/man/day).
(2) N stands for positive control (3000 Cal/man/day).
(3) ST. stands for negative control (starvation).
(4) A stands for 0% Prot., 100% Carb., 0% Fat.
(5) B stands for 30% Prot., 0% Carb., 70% Fat.
(6) C stands for 2% Prot., 20% Carb., 78% Fat.
(7) D stands for 16% Prot., 82% Carb., 33% Fat.
(8) 1 and 2 stand for 1000 and 2000 Cal/man/day, respectively.

The protocol, however, was not designed to test the acceptability of these rations as [illegible] elements. Therefore, if the items of the experimental mixtures became unpalatable and unacceptable, isocaloric substitution of other foods was instituted. This device permitted ingestion of some dietary regimen so that the longest possible period of observation (up to [illegible] days) was available for [illegible] the effects of [illegible] deficiency of certain [illegible] nutrients. [illegible] possibility of [illegible] nutrients was [illegible] by the [illegible] on the other hand, it [illegible] for fuller [illegible] of the subjects.

[illegible] the [illegible] had a general diet [illegible] during the [illegible] of nutrition. [illegible] variety, [illegible] the [illegible] of the [illegible] and [illegible] was limited by [illegible] that the [illegible] [illegible] these. [illegible] every [illegible] was given to [illegible] [illegible] to the [illegible] [illegible] to accept (1) [illegible] [illegible] immediately [illegible] the [illegible] [illegible] every period [illegible] [illegible] and [illegible] the [illegible] [illegible] [illegible] [illegible] To the latter the [illegible] especially with excellent and practical ideas.

The [illegible] mixtures studied were [illegible] in Table II. 5. There are [illegible] the rations, ration [illegible], and other foods [illegible] to formulate the several [illegible] the average daily caloric intake, the [illegible] distribution of calories, and the water allowances. At this time the symbols [illegible] throughout this [illegible] subject [illegible] are listed. The symbols have been set up so as to [illegible] information on the relation between the [illegible] and a diet of pure carbohydrate, [illegible] the symbol "D/2 0/0 U 1000."

The caloric [illegible] for the [illegible] and the recovery period are given as actual daily values. The [illegible] calories are the original at in the experimental [illegible]. The percentage distribution of calories in the [illegible] were [illegible] who collected [illegible] [illegible] dietary data. The other percentages are those [illegible] by mixing the several ration components listed in the [illegible].

The present investigation was not concerned with the influence of vitamins on nutrient [illegible] of [illegible] and organs. All survival [illegible] [illegible] with adequate vitamins. It is also probable that even if vitamins were not supplied, their absence would not [illegible] materially the physical deterioration of the castaway [illegible] is restricted within the six-week period

STAT

EXPERIMENTAL NUTRIENT MIXTURES

EXPERIMENTAL RATIONS AND OTHER FOODS USED	CALORIC INTAKE	% DISTRIBUTION OF CALORIES	SYMBOLS USED IN TABLES AND FIGURES
Pre-Period. 5-in-1	c 3600	14% P, 50% CHO, 36% F	PRE, Day 0
Positive Control: 5-in-1	3000	14% P, 46% CHO, 40% F	N 3000
Recovery 5-in-1 plus Ice Cream, Fresh Bread, Oleomargarine, Orange Juice	c 4400	13% P, 48% CHO, 40% F	REC
Negative Control: Starvation	0	..	ST 0
Spice Drops, Starch Jelly Bar, Hard Candy, Jam, Sugar, Crackers	1000 and 2000	0% P, 100% CHO, 0% F	0/100/0 1000 0/100/0 2000
Chocolate Bar, Crackers, Oleomargarine	1000 and 2000	2% P, 20% CHO, 78% F	2/20/78 1000 2/20/78 2000
Meat Bar and Cereal, Biscuit or Crackers, Jelly, Pineapple, Sauce, Hard Candy	1000 and 2000	15% P, 52% CHO, 33% F	15/52/33 1000 15/52/33 2000
Meat Bar	1000 and 2000	30% P, 0% CHO, 70% F	30/0/70 1000 30/0/70 2000
Water Limited: 900 ml./day			L
Water Unlimited: ad libitum			U

TABLE II.5

over which most feeding periods continue. To avoid [illegible] changes caused by [illegible] vitamin intake, two subjects took [illegible] mix, a pill which supplied them with [illegible] quantities of [illegible] vitamins. Pabalate Complex with Vitamin C (Parke Davis and Co.) was used. Each pabalate contained: thiamine hydrochloride, 10 mg; riboflavin, 10 mg; vitamin B_{12}, 1 mcg; sodium pantothenate, 3 mg; niacinamide, 20 mg; ascorbic acid, 50 mg; [illegible] nitrate (N.F.), [illegible] mg; liver fraction No. 2 (N.F.), [illegible]. Periods of [illegible] in blood ascorbic acid were conducted at biweekly intervals as a check. The data obtained is [illegible] Table II.6. It was concluded that [illegible] subjects can be [illegible] for [illegible] periods supplied with vitamins.

S II. 6

[illegible] ASCORBIC ACID
[illegible] mg-%, mg/100 ml)

[illegible]	[illegible]	[illegible]	Recovery
[illegible]	1.4	1.1	
N-3000	1.1 - 1.9	0.7 - 1.6	
ST-0	1.5	1.6	
[illegible] 1000	1.4 - 1.6	1.1 - 1.9	
[illegible] 2000	1.5	1.1	
0/100/0 1000	1.3 - 1.6	1.0 - 1.2	
0/100/0 2000	1.1	1.3	
[illegible]	1.9 - 1.2	1.1 - 1.6	
[illegible] 1000	1.5	1.2	
[illegible]	1.6	1.6	
2/20/78 2000	1.2	1.2	
[illegible]	1.2	1.6	
15/52/33 1000	1.2	1.2	
[illegible]	1.3 - 1.6	0.8 - 1.4	
15/52/33 2000	1.6	1.3	
[illegible]	1.1 - 2.0	1.1 - 1.4	
30/0/70 1000	1.6	1.2	
[illegible]	1.6 - 1.8	1.1 - 1.2	
30/0/70 2000	1.2	1.2	
[illegible]	1.1 - 1.2	1.0 - 1.1	

The Control or Positive and Negative Control. Reference standards used to [illegible] the data collected while these seven subjects [illegible] nutrient mixtures. By definition a fixed [illegible] of 30 Cal/man/day of the final ration was [illegible] the "positive control." This [illegible] was picked as it [illegible] closely [illegible] the subjects' usual diet. The distribution of calories approximated those of the pre- and recovery periods and was [illegible] similar to that reported

STAT
STAT

for voluntary food consumption by troops residing in temperate climates (Johnson and Kark, 1947). Subsequent analysis of the experimental data indicated that the approximate daily caloric expenditure by the subjects was 2000-3000 Calories. The subjects on unlimited water tended to maintain their body weight constant during the 14-day interval on this regimen. Most of the functional data showed little change. In general, then, this positive control fulfilled our idea of a reference standard. A negative standard was also needed. By definition starvation was pictured as the "negative control." This regimen produced marked changes in body weight, nutrient balances, and the functions of organs and systems. It was hoped that the physiological reactions to the eight experimental nutrient mixtures would fall somewhere within the range delimited by positive control and negative control. The more nearly the reactions approached the positive control, the less presumably was the nutritional stress. The more nearly the reactions approached those of negative control, the greater presumably was the nutritional stress. Perhaps evaluation of the data within this conceptual frame would lead to practical information regarding the feasibility of an all-purpose or at least a multi-purpose survival ration.

Rations and Ration Components of Nutrient Mixtures. The 5-in-1 ration: This ration was used as the basic food for the pre- and recovery periods and the "positive control" experimental period. There were several reasons for this decision. The primary one was that this particular ration offered the usual American dietary in a standard and analyzed form. A secondary reason was that the preparation of this ration would take a minimum of time, equipment and personnel. Contained in the ration were approximately fifty items, combined into five menus (Table II. 7).

During the pre-periods, these ration items were used exclusively with the exception of 90 ml of orange juice, 200 ml of milk (made with a national brand of skim milk powder), and unlimited fresh coffee and tea. During the recovery periods, to supplement the 5-in-1 ration, frozen orange juice, white bread, oleomargarine, and skim milk powder were given in unrestricted quantities and vanilla ice cream, in amounts up to 200 gm. To obtain as standard a composition as possible and to keep additional analysis at a minimum, these supplements were of the same brand and prepared in a standard fashion.

1. Orange juice: national brand of frozen orange juice of the Valencia season, prepared by standard dilution (see Appendix III).

2. Skim milk powder: national brand, bought as needed, and prepared by standard dilution (see Appendix III).

3. Oleomargarine: national brand, bought as needed.

TABLE II. 7

5-IN-1 RATION
(Procurement of August 1951.)

Menu #1	Menu #2	Menu #3
Beef & gravy	Beef & gravy	Beef & gravy
Ham chunks	Sausages	Meat balls & spaghetti
Sausage links	Bacon	Bacon
Sweet potatoes	White potatoes	White potatoes
Corn	Lima beans	Green beans
Pineapple	Apricots	Peaches
Cheese spread	Catsup	Cheese spread
Chicken noodle soup	Pineapple-rice pudding	Apple sauce

Menu #4	Menu #5	Items in All Menus
Roast beef	Beef & vegetables	Crackers
Hamburger	Luncheon meat	Jam
Ham & eggs	Bacon	Dry milk
White potatoes	Corn	Soluble coffee
Tomatoes	Peas	Cocoa
Pears	Fruit cocktail	Gum
Catsup	Tomato soup	Sugar
Date pudding	Fruit cake	Candy
Peanuts	Peanuts	

4. Bread: standard white loaf, prepared by a local bakery in two batches and frozen until needed.

5. Ice cream: standard vanilla made by a local creamery in two batches and kept frozen until needed.

6. Cornstarch and white flour: one container of each of a national brand was used during latter half of study to vary the results of the recovery period.

7. Bacon, pre-fried: late in the investigation canned pre-fried bacon (an experimental item from the Quartermaster Food and Container Institute) was used as a substitute for the regular 5-in-1 bacon component. This item is low in salt, a feature which makes for increased palatability. This bacon was only used during the recovery periods.

During the experimental "positive control" period the caloric intake of 5-in-1 ration was fixed at 3000 Cal/day. Only ration items were permitted, eliminating such items as skim milk powder and orange juice. The menus were planned mainly with the limited water intake in mind, rather than a specific caloric distribution. Few menus contained more than 450 gm of water derived from food per day, while the majority contained 400 gm or less. The diets were adjusted as much as possible to the individual preferences. Meats were used at each meal; as were crackers and jam. The high caloric density items such as fruit cake, candy, and peanuts were used to meet the caloric requirements, without elevating the water intake too much. Fruits were virtually eliminated, but at least one vegetable a day was used, since the water of these foods could be concentrated to a small volume.

The total caloric intake of the pre- and recovery periods was not limited. In the pre-period the subjects were encouraged to consume enough to maintain their weights as nearly constant as possible from day to day. The intake of water was ad libitum. In the recovery periods the subjects were allowed to eat and drink qualitatively and quantitatively as they wanted from the foods available among the 5-in-1 ration and supplements. This arrangement was made so as to be able to study the voluntary diet of rehabilitation. The first recovery periods saw a high incidence of acute gastrointestinal complaints attributable to overeating generally or excessive consumption of single foods. After this experience the subjects themselves were more cautious in the rate at which they returned to a full caloric intake. A more detailed discussion of what came to be known as the "post-period blues" will be presented later.

The total caloric intake of the period of positive control was fixed at 3000 Cal/day. Eight subjects were on this regimen, four of them receiving a total daily water allowance of 900 ml (liquids plus water contained in the food) and four of them being allowed water ad libitum (Table II. 8). Seven of the men

TABLE II. 8

[illegible] OF RESTRICTED WATER INTAKE ON EQUILIBRIUM IN MAN AT 3000 CALORIES

Experimental Ration Mixture	Restricted After	Unrestricted Water
3000	4	4
ST 0	4	4
0/100/0 1000	2	2
0/100/0 2000	2	2
5/30/65 1000	1	1
5/30/65 2000	1	1
10/52/38 1000	2	2
10/52/38 2000	2	2
30/0/70 1000	1	1
30/0/70 2000	1	1

completed the full 14 days of the regimen. One man (No. 6) who was on limited water had to be given free water after the fifth day because of acute dehydration (Table II. 9). The details of this condition will be given later (also see Appendix IV).

The five control subjects were also allowed water and black coffee or tea sweetened with Sucaryl Sodium (Abbott) as desired. The intake of Sucaryl varied from zero to 16 tablets per day. This substance has no demonstrable effect on metabolism. Recently Schoenberger and his associates (1963) have reported comprehensive studies of the calcium ions ingested at 5.0 GM/day for 13 days by two volunteer subjects. No significant changes were observed in hematological values, blood chemistries, renal function, and nitrogen, sodium, and potassium balances. The calcium and phosphorus balances were attained in the expected fashion by the extra calcium consumed, (5.05 gm/day). Repeated physical examinations revealed no remarkable changes. The subjects noted that their stools tended to become mushy. Since our subjects did not ingest such large amounts of Sucaryl, it is reasonable to assume that our data likewise were not prejudiced by the use of this synthetic sweetener.

Eight subjects fasted for periods varying from 7 to 11 days (Table II. 9). The men on restricted water started for 7, 9, 10,

TABLE II. 9

TIME EACH SUBJECT SUBSISTED ON DIFFERENT NUTRIENT MIXTURES

Experimental Nutrient Mixture	Water	Subjects' Code No.	Beginning Date	Ending Date	Lapsed Time (Days)
H 3000	U	2	19 Jan.	1 Feb.	14
	U	5	25 May	7 June	14
	U	7	30 Mar.	12 Apr.	14
	U	12	16 Mar.	29 Mar.	14
	L	1	19 Jan.	1 Feb.	14
	L	3	15 Mar.	29 Mar.	14
	L	6	25 May	29 May	5
	U	6	30 May	7 June	9
	L	8	30 Mar.	12 Apr.	14
Sf 0	U	1	16 Feb.	26 Feb.	11
	U	3	16 Feb.	24 Feb.	9
	U	5	2 Feb.	8 Feb.	7
	U	7	2 Feb.	11 Feb.	10
	L	2	16 Feb.	1 Mar.	14
	L	6	2 Feb.	10 Feb.	9
	L	8	2 Feb.	9 Feb.	8
	L	12	16 Feb.	24 Feb.	9
0/100/0 1000	U	5	2 Mar.	13 Mar.	12
	U	7	27 Apr.	10 May	14
	L	6	2 Mar.	13 Mar.	12
	L	8	27 Apr.	10 May	14
0/100/0 2000	U	2	11 May	22 May	12
	U	12	11 May	24 May	14
	L	1	11 May	24 May	14
	L	3	11 May	24 May	14
2/20/78 1000	U	5	30 Mar.	12 Apr.	14
	L	6	30 Mar.	12 Apr.	14
2/20/78 2000	U	8	13 Apr.	26 Apr.	14
	L	12	13 Apr.	21 Apr.	9
15/52/33 1000	U	1	13 Apr.	26 Apr.	14
	U	6	27 Apr.	6 May	10
	L	2	13 Apr.	26 Apr.	14
	L	5	27 Apr.	6 May	10
15/52/33 2000	U	4	19 Jan.	1 Feb.	14
	U	7	25 May	7 June	14
	L	3	19 Jan.	28 Jan.	9
	L	8	25 May	30 May	6
	U	8	31 May	7 June	8
30/0/70 1000	U	8	2 Mar.	15 Mar.	14
	L	7*	2 Mar.	15 Mar.	14
30/0/70 2000	U	1	16 Mar.	29 Mar.	14
	L	2	16 Mar.	29 Mar.	14

* 1000 Cal/day of carbohydrate added beginning 9 Mar. (Day 8)

and 12 days; those on limited water, for 6, 9, 9, and 14 days. For details of their clinical reactions, see Case Histories in Appendix IV.

High carbohydrate (0/100/0): This ration consisted of candy items: spice drops (small spice flavored gum drops), hard candy (sour balls and life savers), and starch jelly bars (large, bland-flavored gum drops). When a substitute was needed, sugar, gum, jam, and canned pineapple were used. Cornstarch was experimented with but not found practical except for an unlimited-water diet.

The subjects ate their candy in any combinations, with the entire allowance for the day weighed out in the morning-tray. The food could be consumed at any time during the day. If the subject could not consume all the ration offered in a given hour (this happened a few times), they were given that day's unfinished portion at the next feeding. (See note in Appendix III).

Some of the subjects on this nutrient mixture, which at the low-calorie (2000-Cal/day) level, (Table II. 3 and 9), was maintaining, 3000 Cal/day sent up to 4000 Cal/day. At 3000 Cal/day they seemed to lose the least weight while at 4000 Cal/day they gained the most weight. (See case histories in Appendix IV).

High fat, low carbohydrate (2/20/78): The initial ration consisted of this food and a high fat content commercial chocolate bar prepared by the Milbrandt and Chocolate Co., Inc., Attic, Pennsylvania. The bars were from Catch 209. Each bar weighed one ounce. Its composition was stated to be:

Chocolate liquid, 12%
Cocoa butter, 54%
Sugar, 34%
Vanillin, 20 gm/100 lb

The preparation and service of this regimen were similar to that for the high carbohydrate regimen. The entire day's allowance was put on the morning-tray and the ration could be eaten as desired during the day. Since the chocolate bar was poorly tolerated, especially at the level of 2000 Cal/day (11 bars), substitutions had to be used. They were started usually at an earlier stage than on any other nutrient mixture.

Oleomargarine and crackers (saltines) were used in such amounts as to maintain both the caloric level and the percentage distribution of calories. Two saltines were used instead of the bread unit of 5-inch bars since they gave a greater surface for the larger segment of oil margarine which had to be ingested. (Menus were given in Appendix III).

STAT
STAT

Two men subsisted on 1000 Cal/day and two on 2000 Cal/day (Tables II, 8 and 9). The men at the 1000-calorie level stayed on the regimen for 14 days and were able to eat all the day's allowance either as chocolate bar or as substitutions. The two men on 2000 Cal/day had considerable difficulty. The subject on unlimited water was unable to consume 2000 Cal/day in the second week no matter how the allowances was prepared. The subject on limited water had to be taken off the regimen after 9 days because of signs and symptoms suggesting biliary dyskinesia, (Newton, 1953; Ivy and Sandblom, 1934). (See Case Histories in Appendix IV).

Meat bar and cereal biscuit (15/32/33): This nutrient mixture was prepared from components of the Ration, Special Survival, so as to approximate the percentage distribution of calories in the voluntary diet of troops (Jolliffe and Mark, 1947). The basic items used were: meat bar (Ration, Special Survival, and AT-2), cereal biscuit (Ration, Special Survival), and candy items from AT-2 or carbohydrate items such as jam, jam, or canned fruit as preferred. (See items in Appendix III). Special sauces (see recipes in Appendix III) were prepared from horseradish and tomato catsup to be used to make the meat bar-cereal biscuit mixture more palatable. For one subject (No. 7) the cereal biscuit became so intolerable that crackers had to be substituted.

This nutrient mixture was usually eaten in three meals, one third of the total being ingested at each of three meals.

Four subjects subsisted on 1000 Cal/day of this regimen and four on 2000 Cal/day (Table II, 8 and 9). At 2000 Cal/day two men continued the diet for 10 days and two for 14 days. At 2000 Cal/day the two subjects on unlimited water remained on the regimen for 14 days. One subject (No. 3) who was on limited water had to be removed from the diet after nine days. Another subject (No. 8) developed symptoms and signs suggesting renal dysfunction and heat exhaustion after 9½ days of limited water. On ad lib. water intake he continued on the nutrient mixture for the remaining eight days. (See Case Histories in Appendix IV).

High fat, high protein (3/6/70): The basic food of this nutrient mixture was the meat bar (Ration, Special Survival, and AT-2). The meat bar is a form of pemmican, and is composed of 50% (by weight) of rendered beef fat and 50% (by weight) of dried lean beef (Stefansson, 1946). In this study the unflavored bar was used. Each bar weighed approximately four ounces. The daily allowance was divided into three portions in amounts desired by the subjects. There were no substitutions in this regimen.

Two subjects subsisted on 1000 Cal/day of the meat bar and two on 2000 Cal/day (Tables II, 8 and 9). One of the subjects (No. 7) who was on limited water became quite debilitated after

seven days of 1000 Cal/day. The decision was made to supplement the diet with 1000 Cal/day of carbohydrate (crackers and jam) and maintain the water restriction. This regimen began on Day 8 and continued for seven days. (See Case Histories in Appendix IV).

2. Preparation of Food

Since the aim of the present study was to simulate field conditions as closely as possible, the preparation of the various rations was a major component of the effort required to make the several diets palatable. Cooking was kept at the minimum required to make the food palatable. The only cooking utensil issued the subjects was a two-pint electric kettle and electric immersion boiler attachment.

Thawing of Ration. At the beginning of the study, the foods of the original ration were issued by simply handing them as they came from the can. It soon became evident that a palatable meal could be made from this ration only by the preparation of special recipes and very time consuming, thus impractical in the emergency periods. When the foods were eaten plain, they were heated in a double boiler or oven (cold-packed), but at preliminary weighing. To keep the ration at a cold temperature and minimum cooking time were used. The fruit in syrup, the beef and vegetable stew and cornmeal pudding in the C-ration metal containers in the cold, and the cold for the duration. Special recipes and combinations were all prepared on the basis of the weights of the individual constituents. These weights were always made to the nearest gram. For instance, in making a beef barbaque, the ingredients, beef and gravy, catsup and tomatoes were each weighed separately. These known weights were added to the weight of the pan. The mixture was concentrated by boiling, to the desired consistency. The pan and its contents were weighed again. The water loss was calculated from the gross weight change, and distributed equally among the ingredients. In this way, the amount of the concentrated product eaten was corrected for water loss so as to give the original weight. The actual weight of the several constituents eaten could be calculated from their percentage contribution to the original mixture. In this way, the original values on the proximate composition of the ingredients could be used, the only change being allowance for water loss.

As another example, when corn and lima beans were mixed, equal weights were used (making sure that vegetable and liquid were in the correct proportion) or whole cans used giving different weights. In the first case, the amount eaten would be divided by 50%, in the second by proportion 40 and 60%, in order to calculate the amount of each food eaten. In every instance, the food intake sheet to be analyzed listed only the separate rations items consumed.

With our present experience, it would be possible to formulate

standardized, precalculated recipes. During the study, however, because the combinations had to be devised to meet a special and frequently changing need, it was simpler to calculate each recipe separately as the occasion arose. Appendix III gives the 5-in-1 recipes in detail.

The one limiting factor in the use of the 5-in-1 ration was that the analytic data available were for the complete contents of each can. This situation meant, for instance, that the water in the vegetables and the syrup on the fruits had to be used completely and in proportionate amounts in order to make possible calculations. Although several ration components could be combined, none could be separated and used separately; e.g., meat balls from spaghetti, noodles from chicken soup stock, or fatty gravy and meat. In only one case, that of bacon, was separation practiced, and then only because it was difficult to handle the material any other way. The procedure employed is described in Appendix III.

Standard procedures for preparing special foods: Certain foods used during the pre- and recovery periods, especially some of the supplements, were used repeatedly in the daily menu. Standard methods of preparing these foods were devised so that the subsequent calculations could be as simple and reliable as possible. These standard procedures are described in Appendix III.

In the case of positive control when the subjects were on limited water, it was essential to remove excessive liquid in some of the ration components as much as possible. This concentration was accomplished by evaporation. The contents of the can were boiled until 15-25% of the liquid had evaporated. If 80% of the food remained, 80 gm (including a proportionate amount of liquid) was used as a serving, but recorded as 100 gm minus 20 gm of water.

High Carbohydrate (0/100/0). No special preparation of this nutrient mixture was required.

High Fat, Low Carbohydrate (2/20/78). No special preparation of this nutrient mixture was required.

Meat Bar and Cereal Biscuit (15/52/33). The meat bar was eaten in either of two ways: (1) fresh from the hermetically sealed foil wrapper or (2) cooked with different amounts of water for varying lengths of time. Those on limited water preferred minimal amounts (10 ml) of water and minimal cooking time (five minutes). Those on ad lib. water preferred generous amounts of water (100 ml) and a longer cooking time (15 minutes). The former method produced a dry, hamburger-like mixture; the latter a soup-like mixture.

The cereal biscuit was furnished in a wax wrapper. Experience revealed that this wrapper did not prevent drying at ordinary room

temperatures (70-90°F). The biscuit was reclaimed by placing in a plastic bag and storing in the refrigerator for several days before use. The cereal biscuit was eaten either as it came from the package or finely sieved and hydrated. Occasionally it was crushed and combined with the meat bar to make a gruel, the consistency of which was determined by the subject's preference.

High Fat, High Protein (3/2/19). The preparation of the meat bar is described in the preceding section.

3. Meals and Servings

The scheduling of meals was designed to approximate as closely as possible the usual habits of the subjects. For standardization of dietary routine the meals were fed on the same dry Thanksgiving Day plan. Every week-end was set aside and used to allow the extra rest on the part of the subjects. The meals were then served generally as follows:

	Ordinary	Special Survival Training
Breakfast	0800	0800
Lunch	1200	1230
Supper	1730	1800
Evening Snack	As desired	As desired

This schedule was made as flexible as possible because special examinations, field trips, or noon classes might disrupt the regularity.

For those diets requiring no special preparation, the day's allowance was placed on the subject's tray each morning. The subject was then free to consume the ration as desired during the course of the day. The subject was free to take part of the ration with him to be eaten between classes or at other times.

Occasionally the subjects had to leave Urbana to attend to personal business. Under these conditions and when the time away was one or two days the subjects were provided with box meals. These absences were planned ahead of time, where possible, to occur only during recovery periods. There were four such occasions so tabulated. One subject was given permission to break diet for five days to attend to personal business. This break occurred in a recovery period without serious loss of significant data (No. 3, recovery from N.U. 3000).

Two exceptions, especially during the period when the men were adjusting to nutrient deficiencies other than positive control, were practically a routine similar to those existing under survival conditions. There people, like primitive people, eat-on-the-go to a considerable extent as most of their time would be spent in escape and evasion or in searching for local edible plants

STAT
STAT

and animals. Mitchell and his associates (1946) have shown that frequent small meals increase one's ability to withstand cold water or overheat above that achieved when three meals a day are eaten.

Distribution of Calories Among Meals. When the subjects were on the pre- and recovery periods, they could eat ad libitum the rations offered, with the exception of the set portion of orange juice and milk, no attempt was made to standardize portions. The original portions could be left, eaten in part, or eaten entirely and even supplemented. After a short time, the dietitians became familiar enough with eating habits to serve portions for individual subjects.

During the several experimental periods, the subjects were fed fixed portions of food in the form of three diets requiring preparation. In general, the portions were so prepared that approximately one-third of the total daily caloric intake was eaten at each of the three meals. As already indicated, when the subjects were fed rations requiring no preparation, they were free to eat the daily allowance as they desired.

Serving and Participation of the Subjects in Selecting Rations. All of the portions served during the regular meal times were weighed by the dietitians. The subjects soon became familiar enough with the weighing of portions to take care of their own late evening snacks. Food could be taken to eat at home or in the hospital. The only food permitted apart from the ration offered was black coffee or tea. Permitting the subjects to use the kitchen at night was the one way of determining ad libitum intake without employing additional dietitians. Each subject who had an evening snack was responsible for properly recording extra food. In a very short time the subjects could request portions in gram weights and were invaluable in preventing errors during meals.

The weight of all solid food was determined by finding the difference between the dish weight served and returned. Each subject received his food on an individual tray, with foods on separate dishes. Cold foods, such as the crackers, jam, fruit, etc., were weighed at room of time and recorded. The hot foods were served directly from the cooking pan to the serving dish and recorded. The weighing was done on a five kilogram scale, giving readings to the nearest gram. When the trays were returned, the dish was re-weighed and that was recorded. During the pre- and recovery periods there was no necessity for the subjects to eat every bit of the food, so that the difference between the weight of the dish served and the dish returned equaled the amount eaten. The larger scale made it possible to weigh out the portions directly upon the dish, rather than transferring it as would have been necessary with the Hanson dietary scale. On occasion, individual casseroles were used and were placed on the trays

directly from the oven. Those contained a serving of standard weight, and each dish carried its own weight marked in wax pencil. During recovery periods, [illegible] served, each subject received his own loaf, and had become used to the meal. This arrangement facilitated sanitation and keeping since each subject could take care of his own needs from the weighed portions on his tray.

During positive control, [illegible] plate [illegible] was weighed [illegible] was [illegible] foods like [illegible] and in the evening.

All liquids, [illegible] were served from [illegible] cups. To facilitate [illegible] were calibrated. A small glass [illegible] and a larger [illegible] 500-ml. mark, and a pint mark.

Milk was [illegible] weighed [illegible] cups on the glass [illegible] Beyond [illegible] and [illegible] Each [illegible] applied to the wax [illegible] thoroughly dried [illegible] without long soaking, the [illegible] three months.

If liquid [illegible] the glass or [illegible] dietitians could [illegible] it in a graduate. This seldom was required, however, for the subjects either could [illegible] the cup or glass or left the liquid at the level of one of the marks.

During each of the experimental diets, one subject was allowed water ad libitum, the other, a total of seven cups, including the water in the ration. The water in the ration varied from 30 ml in the high carbohydrate diet to 60 ml in the fat control diet. When the subjects were on liquid [illegible] they were not allowed to determine how and when they drank the 3000-ml allowance. The amount of water contained in the ration was set on the daily intake so that the subject knew how many ml remained of the 3000 ml he could consume each day.

The chief problem from the point of view of the subjects was [illegible] liquids consumed while [illegible] at the hospital. Collapsible drinking cups were considered and [illegible] examined. This device was abandoned because of its unreliability and its tendency to collapse at inopportune times. Weighed bottles with subjects were provided with [illegible] straws for [illegible] bottles when they wanted them. Some of the subjects preferred [illegible] Laboratory Erlenmeyer flasks. Since devices for measuring the urinary volume cannot

STAT
STAT

be read closer than 5 ml, we felt that a higher order of precision was not required in judging the intake of liquids.

4. Calculations

Forms for Recording Original Data and Calculations. A number of special forms were devised for specific use in this study. They ensured reliability and facilitated the thousands of arithmetical calculations required in the breakdown of the daily food intake into its several nutrients. Sample forms are collected in Appendix VI.

Daily order sheet. This listed subjects' names, the diets they were to receive, and any special orders from the medical officer.

Daily menu and weight sheet: This listed day's food for all subjects in duplicate. The foods in the pre- and recovery periods were listed by name only; and for experimental diets the amounts of each food for each subject were indicated. On this sheet were also noted any special changes in the dietary portions of the pre- and recovery periods, and the correction factors, and sample mixtures (such as portions) which did not require special recipes.

Individual intake sheets: Each subject had his own intake sheet on a clipboard. Food planned for the day was listed together with blank spaces for extra food. The dietitian listed the dish and food weight in the first column. When the trays were served, the clipboards were placed on a table back beside each subject. Seconds, additional food, and liquids were listed by the subject. When the trays were returned to the kitchen, the dietitian recorded the weigh-backs of each food dish. Each day the amount eaten was calculated (by adding original weight and seconds and subtracting the weigh-back) and the fluid intake totaled. Permitting the subjects to record their own additional food and fluid was necessary for the quick service needed to fit class schedules. One dietitian could not manage this task in addition to weighing seconds and extra food and re-arranging and recalculating diets during the 30-minute meal period.

Individual daily dietary analysis form: From the intake sheets the amounts of each food eaten were listed as grand totals for the day. For example, several figures for the intake of crackers were totaled and listed as one value. A vegetable, such as peas, if used plain and in a recipe, was listed as one total figure. The data on the intake sheets and the analysis sheets were double checked for accuracy. On each of those three forms (with the exception of the subjects' recording some data) the dietitians did all of the computing and transferring of data.

After the total amount of each item consumed had been listed

on the analysis sheet, clerical help was used to copy the analysis from specially designed food tables and to total the daily intake. The dietitians checked each total for accuracy (using the factors of 4-9-4 Cal/gm of carbohydrate, fat, and protein, respectively, to check against total Calories).

Individual summary sheets: The totals of each day's intake for each diet period were listed on this form. From these figures the dietitians calculated period or weekly averages.

Preparation of diets: The process preceding the arrival of the subjects for the dietitians' analytical tables for each food item, the basic data for preparing these analytical tables were obtained

1. Quartermaster Food and Container Institute: Record of Nutritive Values, Section 3 all Detachment, 3-in-1. 15-n-1 to 24. 11 Dec. to 1950. (Summary sheet, Form #1, Form #2, Form #3, Form #4, Form #5). Washington, D. C. 1 May 1951

2. Quartermaster Food and Container Institute: Tables of Nutritive Value of Ration Items. April, 1951.

3. Bureau of Human Nutrition and Home Economics, U. S. Dept. Agriculture: Table of Food Composition for the Armed Forces. Washington, D. C. (Unpublished but current).

4. Quartermaster Food and Container Institute: Letter to Commanding General, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. Attn: WCKLP-5 Subject: Pre-fried Canned Bacon. 14 January 1953.

5. Bowes, A deP., and Church, C. F.: Food Values of Portions Commonly Used. 7th Ed. J. B. Lippincott Co., Philadelphia, Pa., 1951.

The data published by the governmental agencies (1, 2, 3, and 4) were used in calculations of the components of the 5-final ration and the components of the survival rations. The data available were for calories, water, protein, carbohydrate, fat, and calcium. Since it was also necessary to know the intake of sodium, potassium, chloride, and phosphorus, this information was obtained by direct chemical analyses of composite samples of the several components. (See Table II, 11 below.) The data of Bowes and Church and individual manufacturers and information obtained by use for chemical analyses provided values for the supplements, special sauces, etc. The information contained in the paper by Mills et al. (1951) provided valuable references for preparing the

STAT

data we obtained on the electrolytes in food.

The water used by the subjects for drinking and that used in the preparation and cooking of food was local tap water. Information (Table II. 10) was supplied on the chemical composition of the tap water of Champaign-Urbana by Dr. T. E. Larson, Head Chemistry Sub-Division State Water Survey Division, Urbana. These values were applied to the summary sheets once the daily water intake had been summated.

TABLE II. 10

MINERAL ANALYSIS OF CHAMPAIGN COUNTY TAP WATER
(Illinois State Water Survey Division)

Element	mg/1000 ml
Calcium	52.8
Sodium	27.8
Potassium	3-4
Chloride	6.0

All figures for the analytical tables were calculated from 100-gram portions, values being carried to one decimal point. Each item was then analyzed per gram to the nearest whole gram figure. The total grams listed varied from the white bread item, giving data for 1-700 gm, to skim milk powder, with data for 1-50 gm. The tables were enlarged from time to time to give data for larger servings than had been anticipated before the study began. These gram tables made it possible for clerical workers to list the analysis of each item on the individual sheets prepared by the dietitians. It provided a method of rapid analysis with minimum time on the part of dietitians.

Special Devices of Calculations. In the case of some foods special procedures were adopted for standardizing the calculations. These standard procedures were:

Orange Juice: The data sheet for this item gave values for the diluted juice (200 gm of frozen juice and 550 ml of water). The actual amounts of the diluted juice consumed were listed.

Milk: The data sheet listed values for the dry skim milk powder, the dilution having been standardized as 100 gm of milk to 900 gm of water. On the daily intake sheets, the dietitians inserted a decimal point to reduce the figure to the weight of dry powder. The remainder was added to the water intake column. On the daily analysis sheet the total for the day was listed as the dried milk.

Cocoa: The 5-in-1 tables listed the analysis for dry weight.

The intake was listed as such on the intake sheet. When the cocoa was used to make a thick syrup for chocolate milk or sauce for ice cream (3:1 mixture), the intake sheets listed it as chocolate syrup which the dietitians totaled for the day and listed as 25% powder and 75% water (to be put in the fluid intake column).

Soups: The two soups in the ration and the bouillon used as a supplement were listed in the data sheets in concentrated form. Unless used as part of a recipe, the soups were always diluted with the equal amount of water. On each intake sheet, therefore, the figures for soup were divided in half. The water was recorded in the water intake column.

Peanuts: This food item was listed as such on the data sheets. The nuts were used to fill up some of the cream puff chocolate eclairs and were made into peanut butter by grinding the nuts with salt in a home grinder in a 3:1 mixture. On the daily intake sheets the dietitians totaled the peanut butter for the day, listing 75% as nuts and 25% as glace-containing. The servings were added to the rest of the intake for the day's menu on the daily analysis sheet as one figure for each item.

Bacon (5-in-1): This was the one item that could not be used as it came prepared in the ration. Many other items could be used without changing the basic nature of the diet. At first, the fat collected from frying the bacon was distributed as an item in other food items, in proportion to the amount of bacon eaten by each subject. Because of the high fat content of so many other items, this subterfuge caused the foods to become quite unpalatable. Because fat was the only constituent lost in cooking (although a small amount of water was probably lost, too), it was decided to discard the fat and subtract this from the analysis. This was done by listing the weight served as uncooked bacon, minus the amount of fat fried out. For example, if four 100-gm portions gave a total of 200 gm of clear fat, each portion was listed as -50. For purposes of calculation, the 100-gram figures were used with the exception of the fat and calories. The 50 gm of fat discarded were subtracted from the datum for fat, and 450 Cal. (50 gm x 9 Cal/gm) subtracted from the datum for calories. Since cooking time, degree of heat, and bacon all contributed to changing the amount of fat obtained, no standard figures were used. Rather the amount per serving was calculated each time. This procedure was less time consuming than preparing the bacon by a standard method.

Stewed (boiled) bacon: This bacon was low in water and salt. Since the original data were given as the raw food and not whether in its raw (reference A above) agreed with ours, we took up the data sheet accordingly. This item was cited only to be warned (losing just 20% of its fat). The less the water needed as the pre-warmed weight. The necessary fat had already been subtracted from the data sheet.

STAT
STAT

The Calculation of Special Recipes. A data book was maintained listing each mixture made that was not standard. The individual ingredients were calculated within 2 hours to give the amount of each item used per 100 gm. These figures served as a basis for making entries on the intake and analysis sheets.

In the case of a simple procedure, such as concentrating the water from a can of white potatoes (preparatory to making mashed potatoes) the weights of the entire contents of the can before boiling and after boiling were recorded and calculated in terms of percentage water-loss. This factor was used to determine the individual intake corrected for loss of water. For example, if the potatoes were concentrated to 75% of their original weight, and a subject ate 100 gm as mashed potatoes, the amount recorded would be 133 gm of potato, - 33 gm of water. (100/0.75 = 133; 133 - 100 = 33).

In the case of a recipe which contained several items, the amount of each ingredient was recorded in the data book, and the percent of each item calculated. Thus, a meat and vegetable soup with six or eight items would be calculated on each intake sheet and listed in the analysis sheet as amounts of each item contained in that soup.

On the individual daily analysis sheet, the changes in water and weight were all listed so that a total of the columns would give an accurate figure. For instance, bacon was listed in the weight column as -50. The potatoes were listed in the weight column as 133, and in the water column $-\frac{100}{100}33$.

Although throughout the study it was necessary to adhere to certain foods and methods of preparation, as much leeway was granted as possible to make the rations acceptable and to fit individual preferences and schedules.

5. Chemical Analysis of Foods

A number of the foods used in this investigation had to be analyzed directly, for there were no figures available on their proximate composition. All of the military ration components had to be analyzed for sodium, potassium, phosphorus, and chloride. The special supplements were analyzed for nitrogen and minerals. Fat, carbohydrate, and calorie values were taken from Bowes and Church. The chemical analyses were performed by Mr. R. D. Evans.

Preparation of Food for Analysis. In the case of the canned components of the basal ration (except the bread unit, peanuts, jams, and jellies), the entire contents of the can were weighed, mixed in a Waring Blendor, and diluted to an appropriate volume with distilled water. A representative aliquot was taken for

analysis. In the case of [illegible] components [illegible] were taken, [illegible] blended, and diluted to an appropriate volume. The several candy items (chocolate bar, fy-e-nil, caramel nougat, gum, etc.) were treated similarly to the canned components. Frozen aliquots of the special foods were taken, blended, and diluted to an appropriate volume. The components of the survival rations (cereal biscuit, meat bar, chocolate bar, and candies) were analyzed for nitrogen on all [illegible]. Representative aliquots of these items were [illegible], and diluted to an appropriate volume.

Chemical Analysis.

[illegible] (Conway, [illegible] and Wyatt, 1941).
[illegible] (Kramer, [illegible] and Tisdall, 1921). [illegible] according to [illegible] and Hoffman, [illegible] the Perkin-Elmer [illegible] spectrophotometry.
[illegible] mg (Kramer, Tisdall, and Wyatt, 1921).
[illegible] (Kramer, Tisdall, and Wyatt, 1921).

Results. The results are summarized in Table II. The concentrations given are [illegible] of original food. Calculated concentrations are [illegible] ing of [illegible] components as a check on [illegible] nal sis. In general, the [illegible], and chemical published by experimental agencies (refer [illegible] above).

The data on sodium and potassium obtained in our hands did not agree with published values (see reference 5 above) and when balances were calculated, they proved to be consistently negative. Review of our procedures indicated that our muffle furnaces had probably operated at too high a temperature and that sodium and potassium had been lost by volatilization. The analyses for sodium and potassium will be repeated. The data for sodium and potassium will be reported at a later date.

Data on the protein content of the experimental components and the special supplements obtained by direct analysis. The protein (N x 6.25) content of these foods was: meat bar, 42.7 gm/100 gm; cereal biscuit, 11.5; experimental chocolate bar, 1.9; candies (spice drops, starch jelly bar, etc.), 0.0; ice cream, 4.2; bread, 1.4; flour, 10.5; bouillon cubes, 35.1; Sta-Lac (Borden Co.), 35.1; orange juice, 2.7; oleomargarine, 0.4; and saltines, 1.0.

6. Acceptability and Palatability

Although this investigation was not designed primarily as a study of the acceptability and palatability of rations and ration components, it was evident that data bearing on these would inevitably become available during the long period the subjects

STAT
STAT

TABLE II. 11

CHEMICAL ANALYSIS OF RATION COMPONENTS AND SPECIAL SUPPLEMENTS

Food Item	Calcium mg/100 gm	Phosphorus mg/100 gm	Chloride mg/100 gm
5-in-1 Components			
Pork and gravy	20	125	710
Hamburgers and gravy	10	95	650
Pork sausage	10	170	1000
Ham chunks	15	135	1520
Vienna sausage	10	90	1200
Beef and vegetables	10	100	1170
Luncheon meat	10	95	1970
Ham and eggs	45	130	1120
Roast beef	20	120	1640
Beef and gravy	20	150	1270
Spaghetti and meat balls	15	85	1020
Bacon	15	45	2350
Lima beans	25	80	500
Tomatoes	10	25	210
Peas	25	65	500
Green beans	50	20	330
Sweet potatoes	25	15	100
White potatoes	10	40	900
Corn	0	65	350
Pineapple rice pudding	45	35	480
Apricots	10	20	130
Pineapple	15	10	90
Fruit cocktail	10	10	0
Fig pudding	150	85	370
Peach halves	5	15	0
Date pudding		90	350
Fruit cake		80	160
Pears	10	10	0
Tomato soup	20	30	985
Chicken noodle soup	15	45	1120
Powdered milk	1000	435	650
Cocoa beverage powder	360	410	810
Cheese spread	340	375	2320
Bread unit		125	1800
Cereal bar, Type B	190	400	1200

TABLE II. 11 (cont.)

Food Item	Calcium	Phosphorus	Chloride
Caramel nougat	95	140	265
Pootsie roll	70	55	270
Sweet chocolate bar, Type XII	160	185	135
Gum		10	130
Peanuts	75	420	700
Jam	10	10	60
Catsup	10	45	625
Components, Other Rations			
Meat bar	20	360	440
Cereal biscuit	110	400	195
Experimental chocolate bar	0	55	0
Candies (spice drops, starch jelly bar, etc.)	0	0	0
Pre-fried bacon	15	80	2250
Special Supplements			
Horseradish sauce	35	45	1660
Tomato sauce	45	50	1660
Ice cream	90	100	105
Bread	110	100	650
Flour	30	100	765
Bouillon cubes	45	30	485
Starlac (Borden Co.)	1020	970	810
Orange juice, frozen	45	60	40
Oleomargarine	50	25	1530
Saltines	185	200	1850

were under observation. Therefore, an attempt was made to devise methods which might yield practical quantitative information. For this purpose one of the psychological techniques was set up to obtain data (1) on the rank order of preference for the several experimental ration components and (2) on the changes in that rank order which might occur during the course of the investigation. This paired-comparison device is described in detail in the section in Psychological and Psychomotor Tests. Additional quantitative data might be obtained from an analysis of the amounts of the several 5-in-1 components consumed at later and later stages of the study.

Qualitative information was obtained (1) by observations made by the dietitians during meal times, (2) by discussions with the subjects, and (3) by study of diary entries. Of course, the most significant data would be obtained from the clinical reactions of the subjects. Such statements as "This stuff tastes like wax.", "I had to carry a bucket around all day because of nausea", "My

STAT

throat feels like sandpaper.", "The stuff sticks in my throat for hours.", etc. reveal clearly a definite reaction. Whether it be merely psychological or functional in origin remained for a critical evaluation of all the pertinent data.

D. COLLECTION AND PRESERVATION OF SPECIMENS

Three types of specimens were collected: (1) food, (2) excreta (urine; feces, and vomitus), and (3) blood. Each was handled in a standard fashion according to the accepted practices of clinical investigation.

1. Food

Flow-In-Gas. Since there were available no data on the concentrations of Cl, I, Na, and K in any of the components of the 5-in-1 ration, one carton each of the five menus was set aside for chemical analysis. Many water - thods of preparation were required, for the chemical analysis began immediately the components were opened.

Supplemental Special Issues. Aliquots of the several supplements (orange juice, salt, milk powder, ice cream, etc.) and special issues were stored in the deep freezer compartment of a refrigerator in paraffin-lined containers until chemical analysis was done. No special preservatives were added prior to storage.

2. Excreta

Urine: Daily 24-hour urinary specimens were obtained from each subject throughout the entire period of study. The 24-hour period extended from approximately 0700 to 0700. It varied with the difficulty subjects but always ended before breakfast. The urine was collected in clear glass "gallon jugs" or "reagent bottles" to which had been added approximately 5 ml of toluene. The collection bottles were either stored at room temperature in a rack in the toilet used by the subjects or carried by the subjects while they were away from the Hospital. After training it was possible to provide the subjects with smaller bottles which they could carry in their pockets or elsewhere while away from the Hospital. These portions of the 24-hour urine were carefully transferred to the main daily bottle before the end of the collection period.

At the termination of each 24-hour period, the volume, specific gravity, and temperature of the several specimens were measured. If the volume was less than 2000 ml, it was made up to 2000 ml with distilled water and thoroughly mixed. Aliquots were taken for chemical analysis:

Un-pooled aliquots: On appropriate days (Figure II. 1) aliquots

of the 24-hour specimen were set aside for such determinations as urinalysis, sediment, creatinine, creatine, titrable acidity, hydrogen ion concentration, and freezing point depression. These aliquots were pinted in wax-wrapped bottles and stored in the refrigerator until the analysis had been performed.

On days when the "two-hour test" (vide infra) was conducted, a special fraction of the day's specimen was obtained. The volume of this specimen was measured. A 50 ml aliquot was taken for the following (creatinine, nonprotein nitrogen, ammonia, and chloride). The remainder of the specimen was transferred to the regular 24-hour bottle. Since acidifying the specimen with sulfuric acid interfered with the Folin-Wu nonprotein determination, no preservative was added to the 50 ml aliquot. The 50 ml's constituted the specimens which were carried within a few hours. The specimens were refrigerated. Analysis for ammonia was done within 24 hours, the others within another five.

Pooled urine: A series of pooled specimens was made by transferring aliquots of the daily specimens to a nine-liter pyrex "gallon jug" containing about 15 ml of toluene. The collection bottle was kept at room temperature in the toilet during the pooling period. The several aliquots were thoroughly mixed and specimens were transferred to smaller pyrex, brown-glass bottles and refrigerated until chemical analysis was performed (total nitrogen, chloride, phosphorus, sodium, potassium, and 17-ketosteroids). If a subject was removed from an experimental diet before the termination of a two-day period, two pooled specimens were prepared: the first representing the days of the experimental period, the second the days of recovery. The regular seven-day pool was started at the beginning of the next week.

From two subjects (Nos. 1 and 6) two 2-day and one 3-day pooled urinary specimens were prepared each week, 150 ml aliquots of the daily urinary specimens being added. These three pools were separately mixed with toluene, transferred to pyrex brown-capped bottles and refrigerated until analysis for 17-ketosteroids was conducted.

Twenty-four hour specimens (separately voided from pool): On two occasions the urine of each subject was not included in the pooled urines: (1) When the water-diuresis test was performed the urine collected on that day was omitted from the pool since it was thought that the resulting diuresis might result in the incomplete excretion of the substances being measured. (2) When the body-space compartments were determined, the urine collected was omitted. It was found that the additional water intake (used for determining extracellular volume) interfered with the measurement of 17-ketosteroids.

Calculations on the analytical data from the pooled urinary specimens: Since a fixed percentage of the daily urinary specimen

STAT
STAT

was not taken, an empirical calculation was required to convert the data on amount per unit volume to amount per day. This operation was done by a series of factors: (1) The concentration was first expressed as amount per 2000 ml. (2) The average time of the several collection periods was determined from the daily collection periods during which aliquots had been added to make up the pooled specimen. The daily collection period was calculated to the nearest quarter of an hour. The average time was calculated to the nearest 0.1 of an hour. The factor used was 24.0 hr/average time. Since the average time usually ranged between 23.8 and 24.2 hours, this factor was usually small. (3) When the urinary volume was less 2000 ml, the urine was diluted to 2000 ml and 300 ml of the mixed specimen was taken as an aliquot for the pool. If each day's urinary volume was less than 2000 ml, no correction factor was required. A fixed percentage of the daily total would have been added to the pool. It was expected that this procedure would cover all the subjects' daily output of urine. One subject, however, quite consistently excreted more than 2000 ml. Other subjects did this occasionally. In these cases, the 300 ml aliquot was taken from the undiluted urine. Under these conditions the aliquot taken was no longer a fixed percentage of the daily output. The empirical factor - the aliquot factor - was devised so as to calculate the daily output of several substances tested. The aliquot factor was calculated according to the following equation:

$$\text{Aliquot factor} = \frac{3}{1/v_1 + 1/v_2 + \ldots + 1/v_6}$$

Where v_1, v_2, etc., are the daily urinary volumes (in liters) for the period of the pool. (Most of pools were six days long because of the omissions discussed above.)

It follows that the concentrations would then be converted to the amount excreted per day by the formula:

$$S = 2 \times C_m \times \left(\frac{3}{1/v_1 + 1/v_2 + \ldots + 1/v_6} \right) \times \frac{24.0}{\text{average time (hr)}}$$

Where S = mean rate of excretion for period and C_m = mean concentration (amount per liter). The derivation of this equation is discussed below in the section on validation of methods. The error introduced was about 2%.

Feces. Fecal specimens were generally collected for seven-day periods. A carmine marker was taken with breakfast each Monday morning. Successive markers were used to identify the beginning and ending of the periods. The fecal specimens were placed in wide mouthed brown bottles which were stored in the refrigerator when not in use. At the end of the collection period the specimen was mixed

with water in a waring blender and then a milk churn. The final volume was determined by the container. Generally dilution to 4000 ml yielded a fecal slurry which could be handled by the analysts. A small volume of caprylic alcohol was used to reduce foaming during mixing and dilution. An aliquot was taken for analysis. The aliquot was put in a screw-cap amber glass bottle in the refrigerator. No preservatives were added.

Frequently [illegible] objects [illegible] Specimens [illegible] intervals that it was not possible to collect a [illegible] specimen. [illegible] the [illegible] subjects kept, bulky [illegible] which would have [illegible] to empty [illegible] specimens [illegible] carmine [illegible] were used to [illegible] collections [illegible] all the [illegible] to the [illegible] experiment.

Urine. On the few occasions when [illegible] collection [illegible] were [illegible] carmine [illegible] urine [illegible] were [illegible] on the material.

3. Blood.

Venipuncture. All specimens of blood were taken by venipuncture. Stasis was maintained in all cases. This procedure was required because, when the subjects were on a regimen of limited water and low calories, the veins were frequently collapsed, were difficult to enter, or would contract after a successful puncture. All the venipunctures were made with a sterile 20-gauge needles and the blood was drawn into sterile [illegible] of appropriate size. Stark-alcohol [illegible] was used to [illegible] the skin surface, which was wiped dry with sterile cloth prior to the puncture.

Whole blood. This [illegible] blood was used for several analyses. [illegible] differentials were performed by planting [illegible] the first few drops of blood from the needle on [illegible] slides placed in screw-capped [illegible] containing dry [illegible] (sodium and ammonium [illegible] and recording [illegible] formula of Wintrobe (1949) was used for [illegible] analyses (hemoglobin, [illegible] rate, hematocrit, [illegible] platelet [illegible] counts, red and white blood cell counts), clinpac, and ascorbic acid. All these analyses were carried out within a few hours after drawing the blood.

Serum. All other clinical analyses on blood were made on serum. The serum was obtained by allowing the blood to clot in a centrifuge tube, freeing the clot with wooden applicators, and centrifuging to separate the serum from the clot. The clear serum was transferred to screw-capped vials which were stored in the refrigerator at 5°C. Analyses for all [illegible] substances (proteins, creatinine, etc.) were

STAT

completed within a few days. Longer periods frequently elapsed before the several minerals had been measured.

E. NUTRIENT AND OTHER BALANCES

By definition a nutrient balance is calculated according to the general equation:

Nutrient Balance = Intake - Output; where the units are amounts per interval of time.

In order to calculate the balance all the elements of the intake and of the output must be known. The elements which contribute to each are listed in Table II. 12. Not only must the gross intake be known; e.g., grams of food eaten or volume of fluid drunk but also the composition of the intake, especially with regard to the nutrients in question; and similarly for the output.

TABLE II. 12

NUTRIENT BALANCE SHEET

Components of Nutrient Intake	Components of Nutrient Output
1. Food	1. Excreta
2. Water	a. Urine
a. Water in food	b. Feces
b. Liquids	c. Vomitus
3. Injections	d. Perspiration
4. Medicaments	e. Loss of hair, nails and skin
5. Catabolic processes	
a. Metabolic water	2. Blood loss
b. Tissue constituents	a. Venipuncture
	b. Bleeding from wounds or lesions

The ideal balance sheet is seldom completely filled out in metabolic investigations. First, the relative order of magnitude of some of the components of the intake and output may be so small as to be negligible. Second, some of the components must be calculated from other basic data in the balance sheet. These derived data (e.g., metabolic water and tissue breakdown) are based on empirical formulas which are further based on assumptions which although classical, are still open to reasonable doubt. Use of these equations frequently requires collection of more data than the particular investigator is equipped to handle. Then approximations are used or the investigator satisfies himself with a "virtual" balance. Third, some of the components are constant enough so that values based on investigations reported in the literature may be used. This device is frequently used for calculating insensible water loss and loss of hair, nails, and skin. These limitations, due to the state of the art, impose innumerable complexities on metabolic study. It is essential, therefore, that all the necessary assumptions made in calculating a nutrient balance be clearly stated.

The term balance will ordinarily be used with reference to calories and acid-base. In the case of caloric balance one needs to know the gross energy in the intake and energy equivalent of the output. Calculation of the latter will be discussed briefly. Acid-base balance is a metabolic process. The term is used here in the clinical connotation, i.e., [illegible] of the addition [illegible] of the [illegible] titrate of (1) the kidneys, (2) respiratory activity, and (3) renal mechanisms.

1. Caloric Balance

Intake. Calculation of the caloric balance was based entirely on dietary information [illegible] the gross caloric value of the rations and portions consumed by the subjects of this investigation (vide supra).

Output. The caloric output was divided into three parts: light activity, moderate activity, and heavy activity. Each of these parts was calculated in a different manner. The basic data used in the calculation were derived from: (1) the subject's daily diary, (2) the subject's pedometer readings, (3) the resting oxygen consumption, and (4) data from the literature.

Each subject maintained a daily diary of his activities. He was instructed to record [illegible] the time of [illegible], sleeping, resting, reading and studying, walking, [illegible] in class, working in laboratories, exercising, etc. The times used to each activity were supposed to be recorded to the nearest five minutes.

Each subject was given a pedometer and instructed to wear the instrument as directed at all times. [illegible] by the total mileage was recorded in the diary.

For the purposes of calculating caloric output, the several activities of the subjects were arbitrarily assigned to one of three categories of activity: light, moderate, and heavy (see Table II. 13). The diaries for each subject were reviewed for periods of six to eight weeks and the daily number of hours spent in light, moderate, or heavy activity was calculated. The average daily values were calculated for each of the six to eight weeks. The average daily pedometer reading was likewise calculated and then the average of miles walked per hour of moderate activity for the same week. A mean value for the miles walked per hour of moderate activity was calculated and this pedometer factor was used

STAT

TABLE II. 13.

CATEGORIES OF DAILY ACTIVITY

Light Activity	Moderate Activity	Heavy Activity
Sleeping	Walking or hiking	Swimming
Resting	Playing golf	Gymnastics
Reading	Bowling	Handball
Studying	Dancing	
Sitting (e.g., meals, classroom, movies)	Bicycle riding	
Working in laboratory		
Riding in motor vehicles		

in calculating the hours engaged in moderate activity for the remainder of the period of investigation. When the pedometer broke down or the subject failed to record the daily value, the diary was again used to fill in the gaps. When both the written record and the pedometer readings were inadequate, an assumed value had to be assigned. This value was the average value for a previous period when the caloric intake was equivalent. This practice was reasonably safe since the subjects, by virtue of their being students, led an extremely regular existence. The remainder of the diary for each subject was then reviewed for periods of heavy work. The average number of hours of such activity was calculated for each seven-day period. Knowing the average daily period of moderate activity (pedometer factor) and of heavy activity (diary), it was possible to calculate the hours of light activity by subtracting the sum of the first two activities (in hours) from 24 hours.

Caloric expenditure of light activity: The resting metabolic rate of each subject was determined once a week under standardized conditions (vide infra). The value for the resting oxygen consumption (l/min) was converted to Cal/hr by using the factor (4.825 Cal/1.O_2) x (60 min/hr) although the respiratory quotient (R.Q.) and the non-protein R.Q. were known, the assumption was made that the R.Q. was constant at 0.82. The caloric equivalent of oxygen at this R.Q. is 4.825 Cal/l (Brody, 1945). It has been emphasized by Brody (1945, p. 312) that such an assumption introduces an error of ± 3.5%, "which is within the limits of experimental error in metabolism measurements." The resting oxygen consumption was assumed to be representative for each day of the week in which it was determined. Furthermore, it was assumed to be representative of the caloric output during light activity as defined. Therefore, the average daily caloric expenditure of light activity in each seven-day period was calculated according to the equation:

Calories of Light Activity = (Resting Caloric Output) x (Average Daily Hours of Light Activity)

Caloric expenditure of moderate activity: A caloric factor for moderate activity was taken from the literature. This factor was 190 Cal/m^2/hr, the caloric expenditure of walking three miles per hour (Newburgh, 1949). Assuming that the body man has a surface area of 1.73m^2, this value becomes a print daily 4.5 Cal/kg/hr. This rate of walking was somewhat faster than the mean rate for the subjects. These factors ranged from 1.5 to 3.7 miles, averaging 2.9 m.p.h. [illegible] it was assumed that the value [illegible] representative. The previously calculated [illegible] daily caloric [illegible] by which [illegible] was then multiplied for each [illegible]:

Caloric [illegible] = [illegible] x (Average Daily Hours of Moderate Activity)

[illegible] for each subject was then [illegible] during periods of heavy activity as defined:

Caloric [illegible] = [illegible] Cal/kg/hr) x (Average daily [illegible] x [illegible] activity)

Caloric balance: The caloric balance is calculated by applying the equation:

Caloric Balance = Caloric Intake - Caloric Output, where caloric output equals the sum of light, moderate and heavy activity.

According to convention, the balance is said to be positive when the intake exceeds the output and negative when the reverse obtains.

2. Water Balance

In computation of water balance, the following general equation holds: Water Balance = Water Gain (all sources) - Water Loss (all sources).

Water gain is calculated from several factors, some of which can be measured directly and others which can be calculated. The factors which are to be used directly are: fluid ingested, i.e., water preformed in food, and water formed from oxidation of the nutrients in respiration (i.e., metabolic water). The factor which must be calculated is the water [illegible] of tissue in the body itself. This calculation is fraught with questionable assumptions.

Water loss is also calculated from several factors, some being measured directly and others calculated. The factors measured directly are urine output, total insensible water loss (i.e., from

STAT
STAT

lungs and from skin), and loss of water in feces and blood. The important variable which is difficult to measure is actual sweat loss.

Water Gain. The fluid intake (orally or by intravenous injection) was measured. The preformed water in the food was calculated on the basis of the references discussed above in the sections dealing with Dietetic Methods. The metabolic water was calculated on the assumption that all of the nutrients consumed were oxidized. The following factors (Newburgh, Johnston, and Newburgh, 1918) were used in this calculation:

Metabolic water from protein = 0.41 x gm of protein.
Metabolic water from carbohydrate = 0.6 x gm of carbohydrate.
Metabolic water from fat = 1.07 x gm of fat.

Water Loss. The urinary volume and the volume of vomitus was measured. The water loss resulting from perspiration was calculated by assuming that 80% of the blood drawn was water. The resting insensible water loss was measured weekly under standard conditions (see section on Combined Procedures below). It was assumed that the hourly loss so measured was representative of the 24 hours and that the calculated daily loss was representative of the seven-day period. The wet fecal weight was measured. The water content was calculated by assuming that 50% of the wet weight of "normal stools" and 70% of the wet weight of "diarrheal stools" was water.

Water Balance. For the purposes of this experiment then a virtual balance was calculated. Because of the questionable assumptions which are made in computing water from tissue (so-called metabolic mixture), such calculations were not made. Under the conditions of the present investigation it was impossible to measure sweat loss. The virtual water balances presented in this report were computed according to the equation:

"Virtual Water Balance" = (Fluid Intake + (Water Preformed in Food) + (Water Derived from Oxidation of Nutrients)) - (Urine Loss) - (Insensible Water Loss) - (Blood Plus Fecal Water Loss)

Interpretation of this water balance must be made with two reservations. First, if sweat loss were great, the true balance might be lower than the virtual. Second, if tissue breakdown were large, the true balance might be higher than the virtual.

3. Nitrogen Balance

Computation of the nitrogen balance involved use of data from chemical analysis of the specimens collected and of data cited in the literature. The balances were virtual to the extent that no measurement was made of sweat loss. The general formula for the calculation was the same as that discussed above.

Nitrogen Gain. The only source of nitrogen intake was the food eaten. The protein content of the ingested foods was calculated from the tables discussed above (see section on Dietetic Methods). Where such data were not available, the ration components were analyzed directly. The protein was converted to nitrogen-equivalent by use of the factor 6.25:

$$\text{gm Nitrogen} = \frac{\text{gm Protein}}{6.25}$$

Nitrogen Loss. Nitrogen was lost from the body as (1) urinary nitrogen, (2) fecal nitrogen, (3) possible blood nitrogen, and (4) nitrogen in vomitus, sweat, hair, nails, and desquamated epithelium. Urinary and fecal nitrogen were measured on the seven-day pooled specimens of urine and feces, the results being expressed as gm N/day. The nitrogen lost in blood withdrawn was calculated by assuming that the total nitrogen in the blood was 1.0 gm/100 ml (Mark, Dam, and Dam Orsan, 1941). Since the vomitus was negligible, it was not analyzed. No sweat was collected. No values were assumed. The combined loss of nitrogen in hair, nails, and skin was assumed to be 0.2 gm/day (Taylor, 1911; Lusk, 1928).

Nitrogen Balance. The nitrogen balance was computed according to the formula:

Nitrogen Balance (gm/day) = (Nitrogen Intake from Food, gm/day) - (Nitrogen Lost in Urine, Feces, Blood, Salp, Hair, and Nails, gm/day).

It will be noted that the nitrogen contributed to the intake by catabolism of tissue was not considered. Since the assumptions involved in making these calculations are not acceptable, no such computations are presented.

4. Fat Absorption

Fat absorption was computed by deducting from the calculated average daily intake of fat in food the total fecal fat, which was measured in each seven-day pooled fecal specimen. Where the intake of fat was zero, no calculation was made. To our knowledge, a negative absorption has no meaning. There is no information that fat is excreted into the gastrointestinal tract. The method of chemical analysis for fecal fat is detailed below.

5. Mineral Balance

The balances were calculated for sodium, potassium, calcium, phosphorus, and chloride. The general form of the equations were the same as those which have previously been discussed. Because of the lack of data on sweat loss, the balances computed were virtual.

STAT
STAT

Mineral Intake. The only mineral for which tabular data were available on the proximate composition was calcium. Where such information was not on hand, the components, supplements, etc., were analyzed directly by standard chemical procedures (vide infra). Local tap water was used for drinking, preparation of supplements (e.g., orange juice and skim milk), and cooking. This water contained appreciable concentrations of minerals (Table II. 10). The minerals contributed by the liquid intake were added to the minerals consumed in the food portion. Those contributed by intravenous injection were considered negligible.

Loss of Minerals. The pooled specimens of urine and feces were analyzed for sodium, potassium, calcium, phosphate, and chlorides (urine only). The fecal loss of Cl was assumed to be negligible (Clark, 1926). This assumption was justified by the fact that fecal Na averaged less than one mEq/day. Clark (1926) likewise found that the feces from subjects living on an adequate diet contained very little sodium. It was also assumed that the loss of these minerals due to venipuncture was negligible in relation to the magnitude of the fecal and urinal loss. Because there was so little vomitus, this material was not analyzed. Since no sweat was collected, there were no analyses on perspiration.

Mineral Balance. The mineral balance was calculated from the formula:

Mineral Balance (Na, K, Ca, P, Cl) = Mineral Intake (Na, K, Ca, P, Cl) - Urinary Loss (Na, K, Ca, P, Cl) - Fecal Loss (Na, K, Ca, P)

The balances were expressed in gm/day.

No attempt was made to compute, on the basis of dubious assumptions, the minerals contributed to the intake by catabolism of tissues.

6. Vitamin Balance

No measurement was made of the vitamin balance. As previously stated, the subjects were given known supplies of these nutrients. Ascorbic acid in the whole blood was measured biweekly and used to check the general nutriture with respect to vitamins. Since the values for ascorbic acid in the whole blood ranged, on the average, above 1.0 mg/100 ml, it could be assumed that the subjects were in positive balance.

7. Acid-Base Balance

An elaborate study of acid-base balance was not made. It was felt that useful information could be obtained on gross and significant changes in acid-base balance merely by measuring urinary

titrable acidity and quantitative pH. Such information was supplemented by quantitative measurement of the urinary ketone bodies.

F. CLINICAL PATHOLOGY

1. Hematology

The hematological determinations were made by standard procedures of clinical pathology. Combined oxalate (Wintrobe, 1946) was used as blood collected by venipuncture with stasis. The subjects were not post-absorptive. Two thick films of blood from the lobe were placed on glass slides and were prepared for staining. The remainder of the blood was placed in a centrifuged vial containing a standard amount of dried double oxalate (sodium and ammonium oxalate, prepared according to the formula of Hepler, 1949). The hematological determinations were all completed within a few hours after the specimens were obtained. The following procedures indicate the manner in which the determinations were performed, the method used, and the modifications introduced in the original procedures:

Red Blood Cell Count (Hepler, 1949).

White Blood Cell Count (Hepler, 1949).

Direct Reticulocyte Count (Crosby, Johnson, and Warwick, 1951).

Direct Platelet Count (Todd and Sanford, 1948).

Differential Leukocyte Count (Fracke, 1947; Todd and Sanford, 1948).

Oxyhemoglobin (Consolazio, Johnson, and Warwick, 1951).

Sedimentation Rate (Wintrobe, 1946; Todd and Sanford, 1948). The sedimentation rates were corrected to an hematocrit of 42% by means of the Wintrobe nomogram (Todd and Sanford, 1948).

Hematocrit (Wintrobe, 1946). The hematocrit was determined with the Wintrobe tube spun in an angle-head centrifuge. The packed red cell volume was read at 20, 30, and 40 minutes or until the consecutive readings were identical. By this technique the true asymptote was measured.

Hematological Indices. The mean corpuscular volume, mean cell content, and the hematocrit, as described by Wintrobe (1946) were calculated. These are the mean corpuscular hemoglobin (M.C.H.), mean corpuscular volume (M.C.V.), and mean corpuscular hemoglobin concentration (M.C.H.C.).

Venous blood collected with stasis was used for all chemical analyses. The blood was delivered directly into special tubes when the prothrombin time was to be measured. For glucose and ascorbic acid, the blood was delivered into screw-capped vials containing dried double oxalate (vide supra). For all other analyses, the serum was collected after centrifuging clotted blood, transferred to screw-capped vials, and stored in the refrigerator. Unless otherwise stated, the subjects were postabsorptive when blood for chemical analyses was drawn.

Prothrombin Time. (Todd and Sanford, 1948; Shapiro et al., 1950). Simplastin (Chilcott) was used in these determinations. The subjects were not necessarily postabsorptive. The prothrombin time was only run during the initial work-up of the subjects and then, as indicated, during the course of the investigation. A "normal" control was regularly run with all determinations.

Cephalin Flocculation (Ham, 1952; Difco Leaflet No. 112). Thromboplastin, Lecto-Cephalin Cholesterol Antigen (Difco) was used in testing the serum. Blood for this determination was collected during the "two-hour" test (vide infra). Although the subjects were not usually postabsorptive during this test, the various procedures were always conducted at the same time of day for each man. Since there were available no known pathological bloods, our only controls were known normal sera and reagent blanks. These controls were always negative under the conditions of our determinations.

Ascorbic Acid (Consolazio, Johnson, and Marek, 1951). Whole blood was used for this analysis.

Glucose (Somogyi, 1930; Folin, 1929). The method for the determination of blood glucose combined the deproteinization recommended by Somogyi (1930) and the reduction reaction of Folin and Wu (1929). Protein was precipitated by addition of sodium hydroxide and zinc sulfate solutions to oxalated whole blood. The resulting filtrate was heated with an alkaline copper solution (Folin and Wu, 1929). After reduction an acid-phosphomolybdate solution was added for color development. The resulting molybdenum-blue complex was compared spectrophotometrically with that of a known glucose standard at 480 mμ (Hawk et al., 1951).

Presumably deproteinization with zinc hydroxide removed non-glucose reducing substances from the filtrate (Somogyi, 1930) and the values obtained in normal, postabsorptive human blood fall in the range of 65 to 85 mg of glucose per 100 ml of whole blood. Tungstic acid filtrates, when similarly analyzed, yield glucose values which are approximately 20 mg. per 100 ml. higher.

Serum Calcium (Consolazio, Johnson, and Marek, 1951).

Serum Inorganic Phosphate (Consolazio, Johnson, and Marek, 1951).

Serum Sodium. The flame photometer was used. Sera were prepared and analyzed according to the Manual of the Perkin-Elmer Co.

Serum Potassium. The flame photometer was used. The sera were prepared and analyzed according to the Manual of the Perkin-Elmer Co.

Serum Chloride (Consolazio, Johnson, and Marek, 1951).

Serum [illegible] Nitrogen (Consolazio, Johnson, and Marek, 1951).

Serum Uremia (Consolazio, Johnson, and Marek, 1951).

Serum Amylase (Consolazio, Johnson, and Marek, 1951). In principle the method of Consolazio et al (1941) was followed. The following modifications made the results more reliable:

1. Starch powder, Soluble (Merck-Harden Co.) was placed corn starch.
2. The phosphate buffer was eliminated.
3. Whatman No. 40 filter papers were used.

Serum Creatinine. The method was an adaptation of those of Folin and Wu (1919) and Peters (1942). The serum was deproteinized by 10% sodium tungstate and 2/3 N sulfuric acid at a 1:10 dilution. In our hands the procedure adopted gave results comparable with the method of Bonsnes and Taussky (1945) as described by Prod and Sirota (1948). In a few recovery experiments the recovery of added creatinine zinc chloride was 100%. Mandel and Jones (1951) report that a 1:4 dilution of serum with Folin-Wu tungstic acid is necessary for maximal recoveries and maximal comparability with those procedures using Lloyd's reagent which removes pseudo-chromogen. With the 1:10 dilution the recovery of added creatinine zinc chloride was about 90% in their hands. Furthermore, the absolute creatinine values tended to be higher than with the procedures employing Lloyd's reagent. Bolgan (1953) also reported that the 1:10 dilution gave somewhat higher values than the dilution recommended by Brod and Sirota (1948). Because of the possibility that our data on serum creatinine may have been too high due to the presence of chromogens, further studies are being made of the several methods of analysis.

Serum Total Protein (Kingsley, 1942).

Serum Cholesterol (Kingsley and Schaffert, 1949). Three forms of cholesterol were determined by this method: total cholesterol, cholesteryl esters, and free cholesterol. The percentage of total which was free and that which was combined (esterified) was calculated.

STAT

Validation: In our hands this method was not a completely satisfactory procedure. This comment, however, is true, perhaps, of most methods involving the extraction of cholesterol from serum into chloroform. It was found, furthermore, that the sera had to be analyzed immediately in order to obtain reliable results. If the serum stood in the ice box overnight, there occurred a small decrease in total cholesterol and an increase of the esters of the order of 25%. Even with the most scrupulous observation of technique the value for the cholesterol esters frequently exceeded that of the total cholesterol. Since these differences were well within the experimental error, especially of the spectrophotometer used, the free cholesterol was assumed to be zero.

Serum Bilirubin (Malloy and Evelyn, 1937). A method was standardized for doing serum bilirubin. The procedure was not sensitive enough to detect changes within the normal range. The method was available, however, in case any of the subjects should develop an elevated icteric index (Todd and Sanford, 1948) or even clinical jaundice.

Serum Freezing-Point Depression (See below under Urine).

2. Clinical Chemistry: Urine.

Urinary specimens were collected and preserved as described above. The procedures employed in analyzing the various specimens are listed below.

Pooled Specimens.

Total Nitrogen (Consolazio, Johnson, and Marek, 1951).

Calcium (Consolazio, Johnson and Marek, 1951).

Phosphate (Consolazio, Johnson and Marek, 1951).

Sodium (Perkin-Elmer Co. Manual on Flame Photometry).

Potassium (Perkin-Elmer Co. Manual on Flame Photometry).

Chloride (Consolazio, Johnson, and Marek, 1951).

17-Ketosteroids (See section on Endocrine Function).

Diluted 24-Hour Specimens.

Titrable acidity (See section on Urinalysis).

Creatine and creatinine (Pister, 1950).

Ketone bodies (Sargent and McArthur, 1953): Technical

difficulties with methodology precluded completing more than measurement of acetone.

Freezing-point depression: It became apparent midway in the investigation that valuable information could be obtained from frequent measurements of the freezing-point depression. A thermometric procedure was devised in which the freezing-point of the biological specimen was depressed and compared with the freezing-point of standard solutions of sodium chloride (C. L. Prosser, personal communication). At weekly intervals urines were so analyzed. Fully diluted specimens from the 24-hour collections were similarly analyzed. The milliosmolar concentration was calculated from the equation:

[illegible] = [illegible] / 1.86

Activity coefficients were applied for the activity coefficients of electrolytes. Minor corrections for dilution and, the coefficients also [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] dilution of the urine was satisfactorily met with reliable results. Such was our experience.

Study of the milliosmolar concentrations revealed a number of significant facts, which will be detailed in a later portion of this report. Because of these findings, it was decided to calculate the milliosmolar concentrations of serum and urine collected in that part of the investigation prior to making determinations of the freezing-point depression. These calculations were based upon the following assumptions: (1) The serum osmolarity could be computed from the sum of the concentrations of Na, K, Ca, protein nitrogen, and whole blood glucose, each expressed as mEq/l. This assumption was justified, for the calculated osmolarities were of the order of 300 mosm/l. Almost identical results were obtained from data on the freezing-point depression. (2) The urinary osmolarity was calculated from the sum of the concentrations of Na, K, Ca, and N in the weekly pooled specimens. The Na, K, and Ca were expressed as mEq/l. (3). It was assumed that the urinary urea nitrogen contributed 85% of the total N. Using the factor total N x 0.90 for converting total N into milliosmols of urea N, it was possible to assign a reasonable osmolar concentration to N. Again the calculated urinary data agreed closely in order of magnitude with the values based on measurement of the freezing-point depression.

Pooled Weekly Specimens ("Two-hour" urine).

Urobilinogen (See Urinalysis below).

Creatinine (Pister, 1950).

Ammonia nitrogen. Measured as free ammonia nitrogen

STAT
STAT

in the two-hour urines was chosen as a measure of renal tubular function. Whether or not changes in this urinary constituent can be directly attributed to alterations in the functional capacity of the tubular cells remains to be proven. Appropriate experiments validating this hypothesis are planned for the near future. The free ammonia was measured by acidifying a known aliquot of fresh urine, distilling off the ammonia in the Koys nitrogen apparatus (Consolazio, Johnson, and Pecora, 1941), collecting the ammonia in standard acid, and titrating the acid solution with standard alkali against phenol red. Validation experiments with inorganic ammonium salts demonstrated that reliable results could be obtained. The results of this determination have been expressed as mg ammonia N/2 hr.

3. Urinalysis

Both qualitative and quantitative procedures were conducted according to accepted clinical pathological methods.

Specific Gravity (Todd and Sanford, 1948); Hepler, 1949). The specific gravity was measured every day. In all instances undiluted urine was used. The temperature of each urinary specimen was measured simultaneously with the specific gravity and the latter was corrected to a temperature of 15.6°C (60°F) according to the method given by Todd and Sanford (1948). This temperature was the calibration temperature of the hydrometers.

Total solids: The 24-hour excretion of total urinary solids was calculated from Haser's (Haser and Vogel, 1854) equation according to Todd and Sanford (1948). The corrected specific gravity was used in making this computation. A nomogram was prepared to facilitate the analysis.

Acidity. Three measures of urinary acidity were employed. In each case diluted urine was used. The reaction was determined quantitatively with nitrazine paper (Squibb) according to Hepler (1949). The pH was determined with a standardized pH electrometer. The total titrable acidity was measured according to Henderson and Palmer (1914). The volumes were reduced by one-tenth. The results were expressed as mEq of total acidity/24 hr.

Albumin (Hepler, 1949). The albumin was measured qualitatively using diluted urine and Exton's reagent.

Glucose (Hepler, 1949). The glucose was measured qualitatively using diluted urine and Benedict's reagent.

Ketone Bodies (Hepler, 1949). Ketonuria (acetone and aceto-acetate) was measured qualitatively using diluted urine and Rothera's reaction.

Blood (Hepler, 1949). Blood was measured qualitatively using diluted urine and benzidine dihydrochloride.

Bile (Hepler, 1949). Bile was measured qualitatively using diluted urine and Smolin's reaction.

Urobilinogen. The diluted 24-hr specimen was tested for urobilinogen qualitatively using Ehrlich's reagent according to Hepler (1949). The urine collected during the "two-hour" test (see supra) was analyzed for urobilinogen quantitatively according to Wister (1935). The Shaffer-Hartmann urine was used. The color development was compared with a standard curve prepared with Ponceau 3R and Patent Violet (Certified). The analytical results were expressed as Ehrlich units (E.U.)/2 hr.

Sediments. The urinary sediment was analyzed quantitatively after the method of Addis (Addis, 1939). The fresh undiluted urine from the "two-hour" test was prepared according to Addis (1939). Intracellular structures were measured: casts, crystals, leukocytes, and epithelial cells (Addis, 1939). The analytical results were expressed as cells or casts counted per 2 hr. In the preparation of the slides of the urinary sediment studied according to the method of Todd and Sanford (1948).

4. Analysis of Feces

Qualitative Procedures. Prior to study, the seventy-hour specimen of feces had been thoroughly mixed and diluted to a convenient volume (approximately 4000 ml). Aliquots which had been refrigerated were used in the qualitative analyses.

Fecal fat (Ham, 1952): In a smear stained with Sudan IV, the red droplets were noted. The following criteria were adopted for recording the results:

0	no stained droplets
trace	one or two droplets in several low power fields
1	one to three droplets per low power field
2	three to five droplets per low power field
3	droplets constituting quarter of visible material
4	droplets constituting half of visible material

Fibers (Todd and Sanford, 1948; Ham, 1952): In an unstained smear the number of meat fibers in several low-power fields was noted. The impression was recorded as fibers per L.P.F. (low power field). A record was also made of whether or not the fibers were digested or undigested.

Occult blood (Ham, 1952): The fecal specimens were tested for occult blood with benzidine dihydrochloride. Occasional tests were made with the less sensitive guaiac reagent. Each time the

tests were made, the reagents were calibrated against a standard dilution of oxyhemoglobin.

Quantitative Procedures. All the chemical analyses were done on aliquots of diluted, blended seven day stools which had been continuously refrigerated prior to analysis.

Total nitrogen (Consolazio, Johnson, and Marek, 1951).

Calcium (Consolazio, Johnson, and Marek, 1951).

Phosphorus (Consolazio, Johnson, and Marek, 1951).

Sodium (Perkin-Elmer Manual of Flame Photometry).

Potassium (Perkin-Elmer Manual of Flame Photometry).

Total fecal fat (Komer, Hainink, and Meyers, 1949).

Validation: In order to determine whether or not prolonged storage in a refrigerator was associated with changes in the total fat content of feces, a special specimen was set aside for repeated analyses. This specimen was prepared (diluted and blended) in the same fashion as the other fecal specimens. It was collected from one of the regular volunteer subjects during the recovery period 16-23 March. Analyses were performed according to the tabulation below. There was no evident alteration of the total fecal fat over a period of 104 days.

Date of Analysis	Time of Storage	Total Fecal Fat
10 April	19 days	16.9 gm/24 hr
29 April	38 "	16.5 "
25 May	64 "	16.8 "
4 July	104 "	16.6 "

5. Liver Function

The functions of the liver are manifold and its functional reserve may allow considerable damage before significant dysfunction can be detected biochemically or clinically. Many laboratory animals survive and continue to live quite normally after hepatectomy involving 75% of the visceral mass. In order to appraise liver function it is essential to utilize a battery of tests, each of which probes a different hepatic metabolic process. Because only small changes, at most, were anticipated, the most delicate tests available were selected for regular use. Supplementary tests were conducted when the clinical status indicated.

Regular Tests. All of these procedures have been detailed in

the section on Clinical Pathology. Here we list those tests which were considered as "liver function tests."

Quantitative methods:

1. Serum cholinesterase
2. Serum total cholesterol and cholesterol esters
3. Two-hour urobilinogen
4. Fasting blood sugar

Qualitative methods:

1. Serum cephalin flocculation test.
2. Gmelin's test for bile.
3. Ehrlich's test for urobilinogen
4. Color of feces.
5. Icteric index
6. Clinical examination

Supplementary Tests. These procedures have been detailed in the section on Clinical Pathology.

Quantitative methods:

1. Prothrombin time
2. Serum bilirubin

Comments on Liver Function Tests. The interpretation of liver function tests is, at present, a matter of considerable debate and study principally because the many procedures have not yet been adequately standardized so that results collected by one group of observers are directly comparable with those of another group. The situation being what it is, each investigator must carefully standardize the selected tests in his own hands.

At a recent symposium on liver disease (Sherlock and Wolstenholme, 1951, p. 71), for example, asked, "Are we testing the participation of the liver in a metabolic process? Or do we mean that in a certain type of metabolic disorder in which we can show simultaneously some sort of pathological process, that the metabolic change is dependent upon that organ damage?" Maclagan (Sherlock and Wolstenholme, 1951, p. 72) remarked that "From the point of view of the flocculation tests I would like to say that everyone who has worked with flocculation tests has always made the point very strongly that they are not strictly liver function tests and it is a matter of convenience that they have come to be so regarded. Positive results can be caused by a number of non-hepatic conditions...." Wuhrmann (Sherlock and Wolstenholme, 1951, p. 72-73) stated that "We believe that the so-called 'liver function tests' involving blood protein alterations are non-specific, but their clinical value is nevertheless well established in regard to the whole clinical picture. In

STAT

plasma protein metabolism of the blood serum under pathological conditions, there is always an inverse unilateral regulation mechanism, that is, in all diseases with no exception there is a decrease of albumin and a simultaneous increase of globulins, and never the contrary. We think that this fundamental biological law is one expression of the adaptation syndrome of Selye."

Flocculation tests: Of the several flocculation tests available --- thymol turbidity, cephalin flocculation, zinc sulfate test, and ammonium sulfate procedure --- we chose the cephalin flocculation test. Although it has long been thought that changes in gamma-globulin were the main factor in altering serum turbidity or flocculation, Popper (1951) emphasizes that there are, in fact, three important factors: (1) qualitative changes in serum albumin, which cannot be detected electrophoretically, (2) depression of turbidity or flocculation by precipitated biliary material, and (3) changes in serum gamma-globulin concentration. In interpreting these procedures it is generally conceded (Maclagen, 1951) that flocculation reactions of plus one or less have no special significance.

Serum cholinesterase: For a detailed review of the clinical significance of measurements of serum cholinesterase attention is drawn to the recent paper by Vorhaus and Kark (1953). These authors point out that although there may be a wide individual difference in the concentration of serum cholinesterase, there is a remarkable intra-individual constancy in the normal well-fed person. No significant diurnal and seasonal variations have been reported.

The enzyme is a mucoprotein which is produced in the liver in parallel with albumin. A rough linear correlation between serum cholinesterase and serum albumin has been reported by several investigators (Vorhaus and Kark, 1953). Of the conditions which depress serum cholinesterase, liver disease, malnutrition, and chronic debilitating disease are the most important. Damage to liver parenchyma is almost invariably correlated with low serum cholinesterase. The depression is greater in chronic than in acute liver disease and greater in liver disease than in malnutrition. Of a variety of liver function tests, the level of activity of the serum cholinesterase reflects most closely changes in hepatocellular function (Vorhaus and Kark, 1953). Starvation, anorexia, debilitating disease, and experimental malnutrition all cause a depression in enzyme activity (Vorhaus and Kark, 1953, p. 710) presumably reflecting "both the extreme protein depletion and the undoubted impairment of hepatocellular function that accompanies cachexia and chronic debilitating disease." Vorhaus and Kark (1953, p. 711) point out that the return of enzyme activity to normal seems to be related to the restoration of tissue mass and a positive nitrogen balance and "speculate that the cholinesterase level may be an index of the overall protein economy of the body." Certain drugs also decrease the serum concentration of cholinesterase:

caffeine, adrenaline, barbiturates, antipyrine, and thiamin.

The cholinesterase concentration may also be increased above normal. The synthesis of protein by the liver cell is in part determined by the level of circulating albumin. When the level is artificially increased above normal, the liver cells "rest." When the level falls, the liver may be stimulated to produce extra protein. A rich serum cholinesterase, as in [illegible] may reflect a maximal effort of the liver to synthesize protein (Vorhaus and Kark, 1953). Nitrogen retaining hormones may increase the serum cholinesterase by as much as 100% (Vorhaus and Kark, 1953, p. 713), a reaction possibly due to "liberation of cholinesterase into the plasma from the breakdown of cells destroyed by the hormone" [illegible] that the break-down in the extracellular phase will [illegible] early in the catabolic phase, which [illegible] might be anticipated.

Other tests: The other procedures related to the bile cycle (urobilin and bilirubin, etc.) and the relationship between liver and cholesterol are well-known. For a [illegible] Gray and Gray (1942).

6. Kidney Function

From a wide range of possible procedures a battery of renal function tests was selected on the grounds that the several procedures involve a minimum risk to the subject and that the protocol's be adaptable to field conditions. All procedures involving continuous intravenous injection and catheterization of the bladder were ruled out. Since the chemical methods used in conducting these renal tests have already been discussed in the section above on Clinical Chemistry, we shall summarize here the method of carrying out the function tests, their limitations, and their interpretation.

Glomerular Filtration Rate. The glomerular filtration rate is the rate at which ultrafiltrate of the plasma is formed in the glomeruli of the kidney. This filtration is the first stage in the formation of urine. The glomerular filtration rate can be measured by use of the clearance technique. Clearance is defined as the volume of plasma which is cleared of a given substance per unit time. Customarily clearances are the dimensions of ml/min. Clearance is calculated from the equation:

$$C = \frac{\text{Urinary (U) concentration} \times \text{minute urinary volume (V)}}{\text{plasma (P) or serum (S) concentration}}$$

Clearance is usually arbitrarily standardized by expressing C as ml/min/1.73 m^2 of body surface (Smith, 1951, p. 43). Because each subject in this investigation served as his own control, the clearance values have not been adjusted to a standard surface area.

In order to apply clearance to the measurement of the glomerular

filtration rate, a substance must be measured which is only filtered across the glomerular membrane. The substance must be neither secreted nor reabsorbed by the tubular epithelium. Clearance then is theoretically equal to the glomerular filtration rate or C = G.F.R.

Creatinine was adopted as the substance by which to measure G.F.R. Endogenous creatinine is neither secreted or reabsorbed by the tubular epithelium (Smith, 1951). If the plasma level of creatinine is elevated from an exogenous source (protein foods or intravenous injection), creatinine will begin to pass through the tubular epithelium by secretion (Smith, 1951). Theoretically then, the endogenous creatinine clearance should be equivalent to the G.F.R.

The reliability of endogenous creatinine clearance as a measure of G.F.R. will depend primarily upon the accuracy with which one can measure creatinine. The serum contains a number of substances other than creatinine which react with the Jaffé reagent (alkaline picrate). These chromogens are collectively called pseudocreatinine and comprise about 25% of the chromogens measured by the Jaffé reaction (Mandel and Jones, 1953), true creatinine comprising the remaining 75% (Smith, 1951; Schoch and Camara, 1952). These pseudochromogens are cleared at a rate lower than the G.F.R. measured by inulin (Smith, 1951). Their presence, therefore, gives falsely low values for the G.F.R. The amount of these substances varies with the nature of the protein precipitant even though added creatinine may be recovered to 100% (Smith, 1951). Devices available for removing pseudochromogen from serum, other than those discussed in the section on Clinical Chemistry, are enzymatic splitting of creatinine and adsorption and elution of creatinine from kaolin and Lloyd's reagent (Smith, 1951). Using the latter procedure, for example, Haugen and Blogen (1953b) found the following to be the case for plasma from eight normal subjects:

Pseudocreatinine,	0.16 (0.05-0.38) mg/100 ml
True creatinine,	0.92 (0.80-1.05) mg/100 ml
Total chromogen,	1.08 (0.92-1.18) mg/100 ml

Normal urine contained no pseudocreatinine (Haugen and Blogen, 1953).

Once a chemical method is adopted for measuring creatinine what reference standard is there by which to judge whether or not the calculated G.F.R. agrees with the true G.F.R.? It is generally accepted by renal physiologists (Smith, 1951) that the clearance of inulin represents the true G.F.R. The average figure from determinations on 258 males is 127 ml/min/1.73 m^2 (Smith, 1951, p. 544). Investigators who have proposed the endogenous creatinine clearance as a useful and reliable clinical renal function test have standardized it in terms of inulin clearance. The agreement has generally been excellent. Some of the recent data are

summarized in Table M. 14.

TABLE M. 14

COMPARISON BETWEEN ENDOGENOUS CREATININE AND INULIN CLEARANCES

Determination of:	Mean ± S.D.	Ratios	Reference
Cl. of Filtrate			
Folin-Wu (1:10)	1.03	[illegible]	[illegible] and Lund (1949)
Folin-Wu (1:4)	1.0 ± 0.1	[illegible]	Brod and Sirota (1948)
Folin-Wu (1:5)	0.84 ± 0.14	[illegible]	Blogen et al. (1949)
Folin-Wu (1:4)	0.95 ± 0.10	0.7 - 1.0	Sirota et al. (1950)
Jaffé reagent	1.01 ± 0.07	[illegible]	Haugen (1953b)

(1) For each ratio the first figure is the mean.

Further validation of the [illegible] was [illegible] by Brod and Sirota (1948). The [illegible] creatinine clearance was not significantly altered by [illegible] of creatine, a finding which would satisfactorily explain [illegible] of creatine excretion was a significant source of error in [illegible] Changes in endogenous creatinine clearance correlate closely with changes in urea clearance and thiosulfate clearance (Blogen et al. 1949).

The reproducibility of the clearance under standard conditions can be inferred from the standard deviation. Blogen et al. (1949) reported that the average endogenous clearance was 105 ± 21 ml/min/1.73 m^2, the extreme range being 67-153 ml/min/1.73 m^2. Sirota et al. (1950) reported a value of 119 ± 23 ml/min/1.73 m^2. The expected coefficient of variation is thus close to 20%.

The significant factors which cause variations in the endogenous creatinine clearance are (1) diurnal cycle and (2) protein content of the diet. Although the [illegible] does not vary significantly during the course of the day, the [illegible] creatinine loss (Sirota et al. 1950). If the clearance is to be calculated from the 24-hour urine, it is, therefore, necessary to draw blood several times during the day; e.g., every 4-6 hours. The chief cause of this diurnal variation is the protein intake (Addis et al, 1951; Camara et al, 1951; Schoch and Camara, 1952). Opinions on the magnitude and significance of these [illegible] differ. Addis et al (1951) state that (1) endogenous creatinine clearance is lowest between 10 p.m. and 7 a.m., (2) the clearance was not significantly influenced by protein intake except when on meat [illegible] was often at breakfast, and (3) the serum creatinine did not vary. Their clearance averaged 122 ml/min/70 kg. Sirota et al. (1950), on the other hand, reported diurnal variations in serum creatinine of as much as 17%: eight subjects, 5% or less, five, 10%, and one, 17%. Camara et al. (1951) likewise reported significant diurnal variations. If the diet contains 75 gm or less of protein the influence of exogenous protein is minimal. Since it takes 4° hours to eliminate the

effect of high protein, the patient should be on a creatinine-free diet for two days prior to conducting a creatinine clearance using a 24-hour urine (Camara, et al., 1951, Schoch and Camara, 1952).

Methods used in present investigation: Endogenous creatinine clearance was calculated in two ways: (1) from the creatinine excretion in the special two-hour urine and (2) from the creatinine excretion in the 24-hour urine collected the same day as the two-hour urine. The subjects were not postabsorptive and they were consisting on one or another of the nutrient mixtures, some of which were very high in protein. Blood was obtained at approximately the mid-point of the two-hour collection period. For each subject the collection periods and venipunctures were made at the same time of day for consecutive tests. Since each subject was used as his own control, this timing tended to eliminate diurnal influences. This single serum creatinine was used for calculating the endogenous clearance both from the two-hour urine and the 24-hour urine:

(1) Creatinine clearance = $\frac{\text{gm of creatinine/2hr} \times 1000}{\text{serum creatinine, mg/100 ml}}$ x minute urinary volume

(2) Creatinine clearance = $\frac{\text{gm of creatinine/24hr} \times 1000}{24 \times 60 \times \text{serum creatinine, mg/100 ml}}$

The values obtained from the 24-hour clearances were used as the standard in this investigation. A special study was undertaken to compare the results obtained from the two-hour test with those obtained from the 24-hour test. The former was proposed as a possible field method. A discussion of the results of this study will be found under the part of Section III (Results) dealing with kidney function tests.

Osmolar Ratio and Clearance. The method for measuring serum and urinary osmolarity has been discussed above in the sections dealing with Clinical Chemistry. The osmolar ratio is defined by Smith (1951) as follows:

$$\text{Osmolar Ratio} = \frac{\text{Urinary Osmolarity (mOsm/l)}}{\text{Plasma (Serum) Osmolarity (mOsm/l)}}$$

One of the ends of homeostasis is to preserve the constancy of the osmolarity of the serum and intra- and extracellular fluids. The normal osmolar concentration of the serum or plasma is about 330 mOsm/l. In the normal state of hydration the osmolar U/P ratio ranges from 1.5 to 2.5. When dehydration threatens, the urinary osmolarity increases, the kidney conserves water, and the U/P ratio increases. The maximum U/P ratio for man is about 4.1 (Smith, 1951). It turns out that the U/P ratio increases exponentially with

decreasing rate of urinary excretion; as the urinary flow increases the U/P ratio approaches 1.0 as an asymptote (Shannon, Prodaky, West, and Mackler, 1949). It is reasonable to assume that two parameters define this relationship: (1) the urinary flow at maximal U/P ratios and (2) the urinary flow at isosmolarity of serum and urine. Renal osmotic work should be maximal at low urinate volumes and least at the isosmotic point (Shannon, Prodaky and West, 1949). Using a log relation, U/P ratio to urine flow it would be possible to define these two terms. Their relationship to the problem of the osmolar clearance will be discussed in Section III. The osmolar clearance as such was not calculated.

Water Clearance. The clearance of water can be calculated from the following formula of Smith (1952):

$$C_{H_2O} = V(U_{Osm}/P_{Osm} - 1)$$

where U_{Osm}/P_{Osm} = the U/P ratio of the above and V is the urinary volume per unit of time. It will be noted only the formula only holds for conditions in which U/P>1. A similar expression was proposed by Pro[illegible] et al. (1952) for [illegible] which it is termed "water economy." The same limitations will [illegible] application of this equation to our data will be discussed in Section III.

Urinary Specific Gravity and Total Solids. The kidney has the ability to [illegible] urine of diluted urine. For many years this has been studied by means of measuring the urinary specific gravity. It was found that in [illegible] specific [illegible] with a wide range from 1.000 to 1.040 [illegible] Smith, 1951, p. 619) [illegible] the state of hydration. In renal disease the [illegible] some final at 1.010 regardless of [illegible] of hydration (Smith, 1951). Since this is a widely used clinical test, we [illegible] it, too; but we agree with Smith (1951, p. 619) that "At best, the specific gravity of the urine is only a blunt index of the degree of concentration because various solutes contribute so differently to the specific gravity." (See also Price, Miller, and Hagan, 1940.) There is no necessary relationship between [illegible] specific gravity and [illegible] the [illegible] [illegible] osmotic [illegible] freezing-point depression will be routinely determined in hospitals.

The total solids can be calculated from the specific gravity by means of a variety of empirical formulae (Price, Miller and Hagan, 1940). We used Fraser's [illegible] Kendel, 1954) [illegible] discussed above. Price, Miller and Hagan [illegible] stated that the formulae were only reliable [illegible] and constant. We followed their advice and calculated only the total solids during experimental periods.

STAT
STAT

Urinary Volume. The volume of urine per unit of time is a good index of hydration and a rough measure of renal function.

Serum Non-Protein Nitrogen. The serum non-protein nitrogen is markedly influenced by the dietary intake of protein (Peters and Van Slyke, 1946). It is low when the protein intake is low and elevated when the protein intake is high. Superimposed is the influence of renal function. The principal pathway of excretion of urea is via the kidney. In renal dysfunction, urea may be retained resulting in elevated serum non-protein nitrogen (Bodansky and Bodansky, 1952). An elevated N.P.N. may also result from extra-renal causes (extra-renal azotemia), such as hemorrhage, vomiting, dehydration, and shock. Here the primary pathophysiology is not renal, indeed the kidney may be normal in so far as more specific functional tests are concerned (Jeghers and Bakst, 1938).

Serum Creatinine. We have discussed the possible influence of diet on serum creatinine under glomerular filtration rate. Renal dysfunction can also lead to an elevated serum level. A number of authors state that concentrations of serum creatinine above 1.3 mg/100 ml indicate renal impairment due to renal disease, cardiac failure, and dehydration (Biggen et al., 1949; Haugen and Bleeg, 1953a). Certainly elevated creatinine is a more reliable measure of renal dysfunction than non-protein nitrogen and in general it indicates a more advanced impairment (Bodansky and Bodansky, 1952).

Quantitative Measurement of Urinary Formed Elements (Addis Count). Customarily a random sample of urine is collected, an aliquot is centrifuged and the sediment is examined under the microscope for the presence of formed elements. This procedure is useful as a screening procedure for renal disease. A more quantitative device is desirable for studying changes in renal function in normal individuals or following the progress of a patient suffering from renal impairment. The principle proposed by Addis was adopted. In brief, a urinary specimen is collected for a known interval of time. A standard aliquot of fresh urine is centrifuged under controlled conditions and a standard fraction is decanted. The remainder is thoroughly mixed thereby concentrating the sediment. The concentrated material is placed in a hemocytometer and examined under the microscope (Ham, 1952). From the results the formed elements may be enumerated as cells/unit of time. Standardization of such a technique must be done by the individual investigator. Normal values are available for reference (Ham, 1952; Lippman, 1952; Table I. 1). In this study the procedure used was standardized in terms of the pre-periods. The values will be presented in Section III.

Method: The urine collected during the two-hour test was used. It was fresh and was analyzed as described above in the section on urinalysis.

Interpretation: When the Addis count is performed it is not uncommon to find occasional red blood cells and casts in urine collected from healthy individuals (Ham, 1952; Lippman, 1952). When does the presence of these elements signify renal pathology? The decision is made on two chief grounds (1) [illegible] comparison of data with normal reference values and (2) careful evaluation of the total clinical pathological picture.

In general there are four types of formed elements in the urinary sediment: casts, red blood cells, epithelial cells, and leukocytes. Casts are formed in the distal portion of the nephron and in the collecting tubule. The casts arise from precipitated protein. There is now evidence (Lippman, 1952) that the glomerular filtrate contains appreciable amounts of protein. Since the protein content of voided urine is low, the tubules must reabsorb the protein. Proteinuria may arise from increased permeability of the glomerular membrane and/or decreased reabsorption by the tubule. Proteinuria and cylindruria (casts) can rarely occur together. The precipitation of protein depends upon a number of factors, concentration of the filtrate, [illegible] (Lippman, 1952). Normal types of casts may be found in the urine. The primary cast is the hyaline cast. Depending on the functional state of the tubule and the rate of urine flow, this cast may partially envelope into the epithelial cast, then granular cast, then finally granular cast, and finally waxy cast. Any one of these casts may include within their substance red cells, white cells, bacteria, epithelial cells, and fat droplets (Lippman, 1952).

Red cells may occur in association with almost any disease of the urinary tract (Lippman, 1952). Their origin is unknown. Since they may appear in the voided urine in the absence of proteinuria, they probably do not pass through the glomerular membrane in the same fashion as does protein (Lippman, 1952).

Epithelial cells can not be distinguished as to point of origin in the urinary tract and it is frequently difficult to distinguish them from leukocytes (Lippman, 1952). Little is known of the physiological causes of variation in their numbers in the voided urine.

7. Endocrine Function

The measurement of the functional changes of the endocrine glands is an integral part of the pathophysiological armamentarium of an investigation of stress. Two general types of procedures are available. (1) A fragment or metabolite of an original hormone or the hormone itself may be measured in a biological fluid, such as blood, urine, or feces. The method may be either chemical or biological (bioassay). (2) A process or function known to be, at least in part, regulated by the activity of an endocrine may be quantitated so that inferences may be drawn regarding the functional

STAT

activity of the endocrine gland. Both types of approaches were employed in this investigation.

Total Urinary Neutral 17-Ketosteroids. The excretion of 17-ketosteroids (17-KS) reflects the functional activity of the adrenal cortex primarily, but the activity of the gonads contribute. These steroids are metabolites of the parent hormones, and they appear in the urine in a free form and bound to (conjugated with) such substances as glucuronic acid. The method devised in our laboratory by Mr. S. W. Marotta and Mr. N. Meltzer measured total (both the conjugated and unconjugated) 17-KS. Our method was a modification of the procedures published by Jensen and Tottermen (1952), Westergaard (1951), and Drekter et al. (1952). The details of this method are given in Appendix I. Analyses were run on weekly pools of urine for each subject. For subjects 7 and 8 three samples per week were analyzed in 2- and 3-day pools. Since some of the urinary samples were kept for variable periods of time following collection, the 17-KS level was determined at various intervals of time. It was found that there was no significant difference in the 17-KS level after 3 1/2 months of storage at 5°C. (Appendix I).

Fecal Steroids. The assumption that the urinary excretion of steroid derivatives of the endocrine secretions can be used as a measure of the functional activity of the endocrine glands can be questioned if it can be demonstrated that significant amounts of similar derivatives are excreted via the gastrointestinal tract (presumably via the biliary system). The problem of extracting and analyzing fecal specimens was undertaken by N. Meltzer of this research team. His method is summarized in Appendix I and has been reported in full in a thesis for the M.S. degree (Meltzer, 1953). His two pertinent findings were: (1) failure to find any 17-ketosteroids in the feces and (2) isolation of corticoid-like material. The former observation suggests that measurement of urinary 17-KS is indeed a good index of endocrine function. The latter finding indicates that quantitative appraisal of corticoid output may require analysis of both urine and feces.

Other Procedures. Most of these procedures have been detailed in other sections. Here we merely list them together with the endocrine glands which may be involved.

Resting metabolic rate: Thyroid.
Serum sodium and potassium: Adrenal cortex.
Serum calcium and phosphate: Parathyroid.
Serum cholesterol: Thyroid.
Blood sugar: Anterior pituitary, pancreas, adrenal cortex, and thyroid.
Eosinophils: Adrenal medulla, (?) adrenal cortex, (?) anterior pituitary.
Lymphocytes: Adrenal cortex and anterior pituitary.
Leukocytes: Adrenal cortex and anterior pituitary.

sugar tolerance test: Adrenal cortex, posterior pituitary, kidney cortex; Thyroid.

Pancreatic function of the pancreas. Serum amylase and serum diastase may be elevated in acute pancreatitis (Bodansky and Bodansky, 1952). Since these enzymes are eliminated and secreted by the pancreas, they were measured in fasting blood in an attempt to gain additional information about the possible influence of the nutrient diet upon pancreatic function.

3. RESPIRATORY FUNCTION AND INTENSIVE WEIGHT LOSS

Observations on respiratory function were made under two contrasted conditions. The first we have categorically defined as "resting." The subject was not necessarily postabsorptive but he was always studied in the same condition and at the same time of day in successive pre- and experimental periods. He rested on a hospital bed in a room maintained at a dry-bulb temperature of 25°-30°C. and a relative humidity of 15-40%. The rest lasted 10 minutes during the last five of which a number of cardiovascular measurements were made. He then mounted a Kinecycle (Exercycle Co.) and was ridden involuntarily for ten minutes (Figure II. 2). The height of the seat was adjusted to a comfortable position. The pedals were at the outer-most location on the wheel and the operating speed was No. 10 on the rheostat. (Other details of this test are given below in the section on Tests of Reaction to Stress.) During the last three minutes of the work period, expired gas was collected in a 120-liter Tissot tank.

1. Collection, Sampling, and Analysis of Expired Gas

A 120-liter Tissot tank was used. Before the beginning of the ten-minute rest, three 1-liter collections and rinsings were made. At the end of the period the gas was mixed with a stirring fan for two to three minutes. The tank was partially emptied and then, with a gentle flow through a rubber tube attached to the

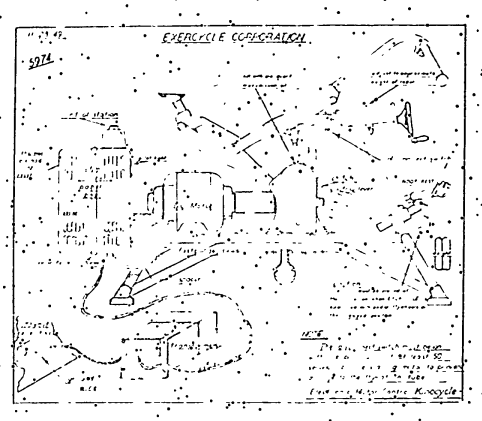

FIGURE II. 2. KINOCYCLE USED IN EXPERIMENTS ON INVOLUNTARY AND VOLUNTARY WORK

sampling valve, a sample was collected in a 50-ml syringe lubricated with mineral oil. The syringe was connected with the tube via a two-way metal stop-cock and a 20-gage needle inserted in the rubber tubing. The syringe was rinsed at least five times with the expired gas before the final sample was taken. The two-way stop-cock was closed at a time when gentle positive pressure was being exerted on the plunger. The composition of the expired gas was determined in the Scholander Micro-Gas Analyzer (Consolazio, Johnson, and Marek, 1951) within six hours after sampling. Mr. Richard Benedix and Mr. Gerald Wegan performed these analyses.

Calculations. The volume of the expired gas was corrected to S.T.P. using the nomograms in Consolazio, Johnson, and Marek (1951). Expressed as l/min this expired volume is defined as the pulmonary ventilation. The oxygen consumption, the CO_2 production and the gross R.Q. were calculated from the formulae and nomograms in Consolazio, Johnson and Marek (1951). The O_2 consumption was expressed in ml/min and was not standardized for surface area since each subject was serving as his own control. The non-protein R.Q. was calculated according to Pagk, Oser, and Summerson (1951) assuming that the mean 24-hr excretion of nitrogen was representative

of the resting period and the period of involuntary work. The metabolic mixtures were determined from Sinton's tables (Roe...cit.).

2. Insensible Weight Loss

The subject was weighed twice during the resting period, the time of each weighing being recorded. The absolute weight was not given. The method of difference was used to determine insensible weight loss. Available were calibrated weights totalling 0-80 gm. The subject was roughly balanced with these weights. He was then accurately balanced with standard weights ranging from one mg to one gm. These weights were left on the pan after the first weighing. The second weighing required only an appropriate subtraction of the standard weights. The insensible weight loss was calculated to the nearest 0.1 gm and 60 minutes.

Insensible water loss. The insensible water loss from the skin and lungs was calculated from the formula of Newburgh et al. (1948):

H_2O loss (gm/hr) = Weight loss (gm/hr) + [CO_2 production (l/hr) - O_2 consumption (gm/hr)]

The rate of insensible water loss is proportional to the total heat loss (Newburgh and Johnston, 1942) according to the formula (Newburgh et al. 1948):

Total heat loss (Cal/hr) = H_2O loss (gm/hr) x 2.37 Cal/gm

The assumption was made that the expired air was saturated at 37°C. On this basis the water lost in the expired air was calculated from the pulmonary ventilation at 37°C, 760 mm.Hg, and 100% relative humidity:

Pulmonary water loss (gm/hr) = Pulmonary ventilation (l/min) x 60 x 0.043 gm H_2O/l

Whether or not the expired air is saturated is controversial (Newburgh and Johnston, 1942; Haldane et al., 1922). When the ambient temperature was 20°-25°C, the temperature of the expired air (at the point of the valves in the collecting device) ranged between 34.4° and 35.7°C. The humidity was approximately 90%. For the purposes of finding whether or not our experimental nutrient mixtures produced any marked changes in insensible water metabolism, we think, however, that our assumption is reasonable.

The calculated insensible water loss was calculated by subtracting the pulmonary water loss from the total water loss.

3. Reproducibility of "Resting" Determinations

To measure the variability introduced into these metabolic data by using the "resting" state rather than the "basal" state; the following experiment was conducted on subjects 9 and 11 by G. Wagan. In the first test-periods the subjects were postabsorptive. Measurements were begun at 0730 and repeated at hourly intervals for the succeeding six hours. Between determinations the subjects were allowed to walk around the laboratory, urinate, and drink water or black coffee. No food was permitted. During the second test-periods the subjects ate a regular breakfast at 0800 and regular lunch at 1200. Measurements were begun at 0830 and repeated at hourly intervals for five hours except that none were made between 1130 and 1230. The same restrictions were placed upon the subjects as in the first test-periods. The metabolic measurements were all made in a room in which the temperature and relative humidity were subject to gross control. During both test-periods the extreme range of temperature was 25°- 30.2°C; averaging 27.8°C; the relative humidity ranged from 33 to 62 and averaged 45%. Of the measurements made, those dealing with pulmonary ventilation, oxygen consumption, respiratory quotient, insensible water loss, and pulse rate have been summarized in Table II. 15. The postcibal

TABLE II. 15

REPRODUCIBILITY OF METABOLIC MEASUREMENTS OF "RESTING" STATE: FASTING VS. NON-FASTING

Determination	Subject No. 9			Subject No. 11		
	M	σ	C.V. %	M	σ	C.V. %
Pulmonary Vent., l/min						
Fasting	5.98	0.35	6.9	4.63	0.35	7.6
Non-Fasting	6.97	0:47	6.7	6.01	0.58	9.7
O_2 Consump., ml/m²/min						
Fasting	140	8	5.4	134	10	7.4
Non-Fasting	169	19	11.0	170	11	6.2
R.Q.						
Fasting	0.80	0.02	2.5	0.83	0.04	4.8
Non-Fasting	0.94	0:06	7.2	0.81	0.03	3.7
Insensible Water Loss, gm/m²/hr						
Fasting	28.6	5.0	10.7	43.4	8.8	20.1
Non-Fasting	26.3	3.8	14.4	34.0	5.4	15.9
Pulse Rate, beats/min						
Fasting	58	2	3.4	70	2	2.6
Non-Fasting	77	6	7.8	76	1	1.3

rise in oxygen consumption (specific dynamic action); pulmonary ventilation, and pulse rate were clearly evident. The R.Q. and the rate of insensible water loss did not vary significantly. Special

attention of the reader is drawn to the standard deviations (σ) and coefficients of variation. Whether basal or resting these two measures of reproducibility of a given determination are of the same order of magnitude. This fact means that use of the resting state did not appreciably increase the inherent variability of these measurements. Variability of the same order obtained when measurements made on the same subject on different days were compared (See Section III).

H. CIRCULATION

Only a small battery of cardiovascular tests was conducted.

1. Blood Pressure

The blood pressure was measured in all instances by means of the [illegible] monitor [illegible] test. Blood pressures were taken [illegible] after the subject had been reclining for 30 minutes and [illegible] exercise-stress test.

2. Pulse Rate

The beats were timed with a stop-watch. The beats per 30 seconds were multiplied by two to give the beats per minute. Resting pulse rates prior to performing work on the kinocycle were calculated from the electrocardiogram.

3. Circulation Time

The circulation time from the arm [illegible] cubital fossa to the tongue was measured by the fluorescein method of Lange and Boyd (1927). This test was conducted in the rest period prior to performing work on the kinocycle. Five ml of Fluorescite (C. F. Kirk Co.) was injected rapidly intravenously.

4. Electrocardiogram

The Sanborn Portable Instrantic Cardiette was the recording device for measuring the electrical changes from the three standard limb leads I, II, and III. An E.K.G. was taken from each subject prior to acceptance as a subject and at the end of the study. During the investigation E.K.G.'s were made during the exercise-stress test (below).

I. [illegible] SYSTEM

An exhaustive review of the literature [illegible] by W. A. Boyd disclosed that there [illegible] no very few quantitative procedures available for assessing changes in the functions of the peripheral

STAT
STAT

neuron. Time did not permit an adequate exploration of this field. In contrast to the paucity of tests on the functional condition of the neuron, there was a mass of literature on psychomotor tests. In general these procedures measured the status of one or more of a number of reflex arcs, the pathways of which varied widely in complexity. A few simple psychomotor tests were adopted on the premise that they would identify any large changes which might occur as a result of subsistence on the different experimental nutrient mixtures. From a large choice of psychological tests a few simple procedures were selected. Finally electroencephalograms were taken at regular intervals.

1. Psychomotor Tests: Reaction Times and Reflex Time

In previous nutritional investigations comprehensive batteries of psychomotor tests have been conducted. In general the changes observed have either been small but statistically significant or equivocal (Glickman et al., 1946; Keeton et al., 1946; Glickman et al., 1946; Keys et al., 1950 and others). Because of this experience, we measured only reaction times to sight, sound, and touch; reflex time (withdrawal reflex) was determined also.

The apparatus used for measuring reaction times for sight, hearing and touch as well as for measuring reflex time is schematically diagramed in Figure II. 3. As can be seen, it consists of two elementary circuits I and II. Circuit I consists of two switches, a simple key (1) and a two-way key (2) connected in series. The circuit also contains two dry cell batteries connected in series and an electric light bulb. Circuit II, connected to the other pole on the two-way switch, consists of an inductorium and four dry cell batteries arranged in series. Circuit II was used to produce stimuli for measuring reaction to sound and touch and for measurement of reflex time.

An electronic timer (Berkeley Interval Timer) was tapped across circuit I to measure the time during which current was flowing in this circuit; i.e., the time elapsing between the application of the stimulus, irrespective of its nature, and the response of the subject to the stimulus. This device, therefore, measured reaction time or reflex time depending upon the manner in which the stimulus was given.

The subject was sitting comfortably at a table for each measurement, operating key (1) with his right forefinger. The subject closed key (1) when he was ready to begin. The operator observed the subject until key (1) was closed and closed key (2) at some short time following. The interval of time elapsing between the closing of keys (1) and (2) was varied so that a true reaction time to the stimulus could be obtained. The subject was unable to observe the closing of key (2).

ELECTRICAL CIRCUIT FOR REACTION AND REFLEX TIME.

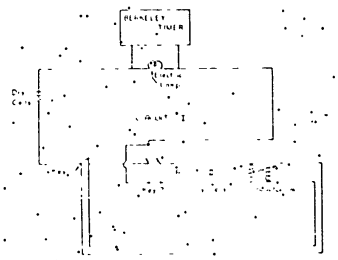

FIGURE II. 3. ELECTRICAL CIRCUIT FOR REACTION AND REFLEX TIME.

The application of the stimulus was dependant upon the direction in which the operator closed key (2). The subject always knew which test was being conducted. The entire test consisted of five consecutive practice trials followed by five experimental determinations, the subject having been informed before the first practice trial what he was expected to do.

For the measurement of the reaction time of sight the subject was informed that at the time key (2) was closed the bulb would light and the timer would begin recording. As soon as he saw the light flash, he was to remove his finger from key (1) thereby putting out the light and stopping the timer. The time during the experimental test was recorded.

The procedures for measuring the reactions to sound and touch and the reflex time were performed in a similar manner, except that the stimulus used was different and the bulb was covered. The sound used was produced by the vibration of the inductorium armature, the inductorium having been connected so that it would produce a tetanizing stimulus. The stimulus for touch resulted from having the subject place his left thumb and forefinger across the secondary binding post of the inductorium and responding to this shock by

moving his right forefinger from key (1). The intensity of the shock was set for each subject so that it was not unbearably painful. The stimulus for measurement of reflex time also was produced by the inductorium, but in this case, two fine wires were led from the secondary binding post through two holes in key (1). Thus the same finger responding was also the one which was stimulated. The resistance of the fine wires necessitated a new setting of the shock-intensity which was also chosen so as not to be unbearably painful.

2. Psychological Tests

(In collaboration with A. L. Michaels and H. H. Weiss)

Although the focus of this experiment was almost entirely on the physiological responses to certain nutrient mixtures it was thought desirable to study some of the psychological concomitants of the dietary regimens employed. Brozek and Michelsen (1949), in reviewing the relationship between the physiology and psychology of the diet in subjects, point out that subjective dissatisfactions with diet is far more important than the question of nutritional deficiencies, and further, that "psychological repercussions resulting from a monotonous diet are likely to be of far more importance than any physiological effects."

Cultural patterns of eating behavior, ideas about food and nutrition learned throughout life are fairly well fixed in the young adult and any sudden shift in eating habits in itself constitutes a stress situation. The subjects, moreover, must forego food preferences and idiosyncrasies developed over many years. Also the subjects could not participate fully in the social life of their peers where food was concerned as exemplified by the coffee break, parties and similar social institutions.

With this in mind a limited psychological investigation was conducted along with the physiological study to determine what attitudinal changes occurred during the course of the experiment. More specifically we were concerned with the changes noted in attitudes toward's self, other members of the experimental group, the "authority figure" responsible for the group's inconveniences, and the experimental diets.

The Tests. The choice of tests was partly determined by the imposition of two restrictions: (1) that they be administered infrequently (once every two weeks) and (2) that they be given within a short space of time; i.e., an hour or less. Since the subjects had to spend a great deal of time participating in physiological measurement and pursue their studies, any additional burden would be unreasonable.

The tests were administered on alternate Fridays following the

evening meal. Since the two groups were out of phase with respect to experimental conditions, one group was tested in the latter part of the control period, within two days of beginning an experimental regimen, while the other group was tested within two days of coming off an experimental period.

Three paper and pencil tests (examples in Appendix "I) were administered: (1) a paired-comparisons test whereby each man rated himself, the other subjects and Dr. Ancel on five personality traits, (2) a paired-comparisons test consisting of 66 items taken from the Allport-Vernon Study of Values, and (3) the Osgood Semantic Differential Scale (Osgood, 1952) where the subjects were required to judge the two participants, various ration components, and other concepts on a seven point scale.

The method of paired comparisons (Guilford, 1936) is quite simple. For example, on the first test the name of each subject was compared with every other subject; as in: Ancel, on the one hand, and Keys, on the other hand, in the matter of the following traits: intellectual ability, tolerance, friendliness, cooperation, and honesty. The subjects were instructed to circle the name of the person in each pair whom he believed was better described by the trait.

A rank order of preferences was constructed from these judgements. The rank-orders obtained during the study gave an objective picture of the attitudes of each subject towards the other subject on the various traits.

Similarly the paired-comparisons test for ration components showed the preferences the subjects held for the various food items during this period. The kind of question this test attempted to answer was: Do preferences for ration components change as a result of being subjected to specific dietary regimens?

Although a more complex treatment of paired-comparisons data can render scale values, as used here it does not indicate distances between ranks. This can be gained from the Semantic Differential Scale. Since full utilization of the information from the Semantic Differential Scale requires a relatively more complex statistical treatment, the handling of the results was modified for purposes of this study. This scale serves to couple at the paired comparisons. The test provides ten opportunities for each person or diet to be rated on a seven point scale. By using certain assumptions; e.g., that a positive attitude would be indicated by marking a person or diet "full" rather than "empty," "deep" rather than "shallow," "fast" rather than "slow," as well as the more obvious choices -- "valuable" rather than "worthless," "pleasant" rather than "unpleasant," etc., we are able to give the scale a range from 3 to -3. When these ten ratings are summed each person and diet receives a scale rating from 30 to -30. Hence, where the paired comparisons provide us with a rank order, the Semantic

Differential Scale provides an indication of the distance between ranks.

In addition to these devices the subject's sense of passage of time was measured according to the method of Hoagland (Hoagland, 1933; Hoagland, 1935; Hoagland and Perkins, 1935). This test was made weekly after the subject had been resting for 30 minutes (see section on Combined Tests below). In short, the subject was handed a stop-watch face down. He was instructed to start the watch when ready and to stop it when he judged the given interval of time to have passed. He was allowed to use any scheme he wanted to judge the passage of time other than his heart or respiratory rate. The results were not disclosed until the end of the investigation. Between tests practicing was not discouraged. Three intervals of time were given: 20 seconds, 45 seconds, and 70 seconds. At each time, only one trial for each interval of time was made. The three values were recorded to the nearest 0.1 second.

Validation of method of judging passage of time: In order to ascertain the reliability of a single judgement of the passage of time, two studies were made with the assistance of subject 9. In the first he judged the passage of 20 seconds, 45 seconds, and 70 seconds 10 times each (Condition A). In the second he judged the passage of these intervals 10 times in the sequence 20-45-70, 20-45-70, etc. (Condition B). The results of these two studies are summarized in Table II. 16. By either approach, the

TABLE II. 16

VALIDATION OF METHOD OF JUDGING PASSAGE OF TIME

Experimental Condition	20 Seconds M	20 Seconds σ	20 Seconds C.V.	45 Seconds M	45 Seconds σ	45 Seconds C.V.	70 Seconds M	70 Seconds σ	70 Seconds C.V.
	Sec.	Sec.	%	Sec.	Sec.	%	Sec.	Sec.	%
A*	19.9	1.0	5.0	53.7	3.0	5.6	77.1	4.9	6.4
B*	20.4	1.6	7.8	50.0	2.9	5.8	73.7	5.8	7.9
A vs. B: "t"		0.26			0.84			0.45	
A vs. B: P		0.8			0.4			0.6	

*A refers to judging each time 10 times.
B refers to judging the sequence "20-45-70" 10 times.

mean estimates did not differ significantly as judged by the "t" test (Rider, 1939). If three times the standard deviation is accepted as the limit beyond which deviations are significant, the single readings must differ by more than 25-30% before any significance can be attached to changes in judgements of time.

Comments of meaning of judgements of time: The large literature on the psychological aspects of estimating the passage of time has

been reviewed by Weber (1937). More recently Hoagland has given this material a physiological interpretation. Hoagland (1933) and Hoagland and Perkins (1935) first showed that judgements of short intervals of time (20 seconds) varied directly with the body temperature. A plot of log (1/time) vs. (1/oral temperature, °Kelvin) yielded a straight line with an Arrhenius constant of 21,250 Cal. This relationship held for a number of individuals over a range of about 7°C of body temperature. On the basis of this finding it was concluded that the estimation of time was controlled by a single chemical reaction or a series of closely [illegible] Hoagland (1935, 1936) concluded that the "physiological time" thus seems to depend directly upon the velocities of certain definite chemical processes, the physiological [illegible] ecologically evolute forming different [illegible] dis of the same time. Because of the modifications of short durations as a function of [illegible] temperature, possibly the slowest of the series of essentially irreversible processes involved in the reestablishment of certain parts of the brain. Longer intervals of time appear to be judged in terms of the velocities of other [illegible] ical reactions [illegible] such data [illegible] the diurnal rhythms. The erratic deceptions of duration evidently [illegible] on slowly accumulating interminable effects of the internal environment [illegible] the body changes." This brief concept of a master chemical clock suggested that the [illegible] used upon the subjects by colonic deficits, [illegible] tion, and mineral nutrient ratios might so change the internal environment as to alter their judgements of time.

3. Electroencephalography

Electroencephalograms were taken from all subjects routinely every other week. With subsequent field tests a miniature used the Grass Junior Electroencephalograph, a portable instrument. With this device one can record the activity of only one cortical area at a time. On the advice of Dr. T. C. Ruch, Department of Psychology, University of Illinois, we selected the occipital lobe for our principle recordings. [illegible] bipolar electroencephalograms were also made with a standard Grass 8-channel electroencephalograph.

J. BODY COMPOSITION

Two techniques are available for study changes in body composition: (1) direct measurement and (2) [illegible] from various physical formulae. The latter have been more widely used than the assumptions made in [illegible] the [illegible] volume. The applicability of these [illegible] to metabolic investigation is limited, for frequently [illegible] empirical constants are not similar. The lack of fully validated generally applicable procedures for studying changes in body composition is one of the most serious deficiencies of metabolic research generally. In so far as the present report

STAT

is concerned, little use will be made of these empirical formulae.

1. Body Weight

The body weight of each subject was measured daily after passing the first morning urine and before eating breakfast. The subjects, clothed only in shorts, weighed themselves on a standard platform clinical scale and recorded their weight to the nearest 0.25 lb. The daily weights were converted to the nearest 0.1 kg by dividing the weight in pounds by 2.2.

2. Body Water

Two compartments of the body water, total body water and extracellular volume, were measured by the dilution principle. (Edelman et al., 1952). The various methods available together with a detailed discussion of their applications and limitations have been reviewed by Edelman et al. (1952), Hardy and Drabkin (1952), and Pitson (1952).

Total Body Water. The total water of the body was measured by two independent methods. As a reference standard we used deuterium oxide. The D_2O concentrations of the injected solutions and of the urea withdrawn were determined by the falling drop technique described in detail in Appendix I. The technical considerations in estimating D_2O in body fluids are discussed in extenso by Schloerb, Friis-Hansen, Edelman, Soloman and Moore (1950), and by Soloman, Edelman and Soloway (1950). As used in the present study, the method of administering D_2O is described below.

The antipyrine space was also measured. It has been claimed that in healthy hydrated individuals the antipyrine space is equivalent to the D_2O space (Brodie et al., 1949; Hurst, Schemm, and Vogel, 1952, and Soberman et al., 1949). The concentrations of the antipyrine solutions (Eli Lilly Co.) injected and of the sodium antipyrine withdrawn were measured according to a modification of the methods of Brodie et al. (1949) and Soberman et al. (1949). The details of the analytical method are given in Appendix I. The method of administering antipyrine is described below.

Extracellular Volume. Sodium thiosulfate space is the current generally accepted measure of the extracellular space. The thiosulfate ion passes to a negligible extent into the cells (Cardoza and Edelman, 1952; Kowalski and Rutstein, 1952). The sodium thiosulfate (Winthrop Stearns Co.; Abbott Laboratories) was administered and measured in the serum withdrawn according to Cardoza and Edelman (1952). A combined "body water" test was developed so that the extracellular and total body water could be measured simultaneously. This procedure is detailed below.

Determination of Fair Spaces. In order to reduce the number of venipunctures required during the course of a determination of these body spaces, the two compartments were measured concurrently. Adoption of this procedure first required demonstration that antipyrine did not interfere with the chemical analysis of sodium thiosulfate and vice versa. In vitro tests showed that in the presence of sodium thiosulfate, accurate determination of antipyrine was not possible. On the other hand, antipyrine did not interfere with the measurement of sodium thiosulfate. Cardoza and Edelman (1952) reported that injected sodium thiosulfate had essentially disappeared from human serum by 60-90 minutes post-injection. This finding was confirmed in two experiments on dogs and one experiment on Subject 12 prior to his inclusion in a regular member of Group I. For this reason, bloods drawn for antipyrine could not be obtained earlier than 120 minutes after completion of the thiosulfate. According to Soberman et al. (1949) antipyrine is still mixed and distributed within the tissues. These investigators found that the first blood not be drawn before 90-120 minutes post-injection. On these bases the following procedure was developed:

Solutions and apparatus:

1. 20% antipyrine (Eli Lilly Co.); 1-2 gm of antipyrine are injected.
2. 10% sodium thiosulfate; 10 gm of thiosulfate injected. Prepared in sterile water according to Cardoza and Edelman (1952).
3. 99.6% deuterium oxide solution in sterile saline (Abbott Laboratories).
4. Sterile water (Abbott Laboratories)
5. Sterile saline (Abbott Laboratories)
6. Sterile volumetric pipettes, beakers, and syringes
7. Sterile infusion apparatus (three-way stop-cock, one 100 ml syringe, one barrel of 50 ml syringe, glass adapter, and sterile intravenous tubing).
8. Ring stand and clamps

Experimental: Most of the body water determinations were carried out in the morning just after the subject awakened. It was the general practice to omit breakfast and avoid large amounts of fluid. This procedure was established after it was noted that during the infusion of antipyrine and sodium thiosulfate a subject who had previously eaten breakfast and drunk large amounts of coffee, water, or orange juice would experience nausea, dizziness and a general exhaustion feeling far more frequently than one who had taken in nothing by mouth before the infusion. The infusions were always carried out in the same room, which was chosen for its uniform temperature, clean atmosphere, and quietness.

The subject lay on an operating table, and he extended his arm onto another table adjacent to the one upon which he was lying. A

STAT
STAT

sterile field was established and the initial venipuncture for the blood blank was obtained. The blood-blank syringe was separated from its needle with great care so that the needle itself would remain undisturbed in the vein.

At the time when the infusion apparatus was assembled the barrel of a 50-ml syringe was attached to the ring stand through a clamp. The vertical outlet of the three-way stop-cock was connected with the syringe. The barrel served as a reservoir for solutions to be infused and for rinsing solutions. A weighed 100-ml syringe filled with 10% sodium thiosulfate solution was connected with the horizontal outlet of the three-way stop-cock. This syringe likewise was attached to the ring stand through a clamp. This system provided a stable arrangement for the infusion of D_2O, sodium thiosulfate, and antipyrine. (The assembly was adapted from a similar one described to us by Drs. J. Schoenberger and I. Yoh Stone, Dept. of Medicine, University of Illinois College of Medicine.) To the outlet of the stop-cock was attached a length of intravenous tubing containing a glass adaptor at the distal end.

While the control blood was being obtained, the tubing and the glass adaptor was filled with saline. As soon as the blood-blank syringe was separated from its needle, the glass adapter was attached to the in-dwelling needle. This manipulation provided saline for infusion so as to prevent coagulation within the system. The solution of sodium thiosulfate was injected at the rate of 10 ml/min or slower if the subject complained of any symptoms.

Ten ml of antipyrine and 30 ml of sterile water were placed in the reservoir syringe, the three-way cock was turned to connect the reservoir syringe with the injection syringe. By drawing back on the injection syringe it was possible to fill it with the fluid contained in the reservoir syringe. The three-way stop-cock was then turned to connect the injection syringe with the in-dwelling needle and the infusion thus recommenced. The antipyrine solution was injected at a rate (5-10 ml/min) which did not cause burning within the vein or strange tastes and burning in the mouth. The reservoir syringe was washed out at least three times with saline solution. This saline was injected in the same manner as the original antipyrine solution.

The injection syringe was replaced with a weighed 100-ml syringe. The volume of D_2O was adjusted so as to give an estimated concentration of 0.2 percent in the body fluids at equilibrium. Usually about 75 ml of pure D_2O were infused. This solution was infused at the rate of 10-20 ml/min and never caused untoward symptoms. The system was rinsed three times with 20-ml aliquots of sterile saline.

At the start of the infusions, in a vein on the opposite arm was placed an in-dwelling needle capped with a small reservoir containing sterile heparin. From this needle post-injection blood samples were drawn for thiosulfate analysis. These blood samples were obtained 20 min, 30 min, and 40 min, after administration of thiosulfate. This needle was then removed.

D_2O reaches equilibrium in the body fluids in approximately two hours (Schloerb et al., [illegible]). Blood samples to be analyzed for D_2O were put [illegible] and 3:0 [illegible] concentration of D_2O.

The bloods for antipyrine analysis were obtained 6, 7, and 7 hours after injection of antipyrine.

[illegible] were [illegible] were removed by centrifugation, and the sera transferred to [illegible] vials with a single use transfer needle.

Sodium thiosulfate: The sera were stored in screw-capped vials in the refrigerator. An aliquot of the originally infused solution was stored in a [illegible] and frozen. Originally these solutions were not analyzed for thiosulfate until several days later. Validation studies have revealed that sodium thiosulfate rapidly deteriorates in sera even when frozen. Thus, our data are not sufficiently reliable to report at this time.

Antipyrine: The sera were stored in screw-capped vials in the refrigerator. An aliquot of the originally infused solution was similarly stored. Validation studies revealed that antipyrine was stable in serum or water at 4°C for as long as two weeks. Chemical analyses were always completed within one week.

Deuterium oxide: The sera were stored in glass ampules, which were sealed in a flame after the sera had been placed in them. The remainders of the infused solutions were preserved in their original containers at room temperature. The stored sera were stored at -15°C.

Calculations:

1. Sodium thiosulfate: The sera concentrations at 20, 30, and 40 minutes were plotted on semilog paper and the concentration at zero time determined by extrapolation. This concentration was [illegible] into the amount of thiosulfate distributed and the thiosulfate space was calculated in liters (Gaudier and Sheehan, 1952).

2. Antipyrine: The serum concentrations at 6, 6, and 7

STAT
STAT

hours were plotted on semilog paper and the concentration at zero time determined by extrapolation. The antipyrine space was then calculated according to the dilution principle in the same manner as the thiosulfate space (Soberman et al., 1949).

3. Deuterium oxide. The concentration of D_2O in the 2.5- and 3.5-hour sera was determined. The mean of these two values was taken as the equilibrium datum. From this figure and the amount of D_2O injected, the D_2O space was calculated according to the dilution principle (vide supra).

Water Diuresis Test. The water diuresis test has been proposed as a diagnostic procedure in the identification of glandular disturbances, notably Addison's disease (Duncan, 1947). We employed the test as a measure of renal function (concentration-dilution data) and of the state of dehydration (percent of oral load excreted in four hours). The protocol for conducting the test was adopted from Duncan (1947).

Protocol:

1. The subject ate his regular diet on the day prior to the test.

2. He was allowed no food or water after 1800. If he was on limited water, he drank his daily allowance prior to 1800.

3. At 2230 he voided into his 24-hr specimen bottle.

4. All urine voided from 2230 to 0730 the following day was collected in a special bottle. This urine was pooled with the remainder of the 24-hr specimen after its volume and specific gravity had been measured.

5. No breakfast was allowed.

6. A urinary specimen was collected, if possible, from 0730 to 0830. The specimen was used as a measure of the basal urinary flow. Volume and specific gravity were noted.

7. At 0830 the subject ingested 20 ml/kg of cool tap water. The total volume had to be consumed within 45 minutes.

8. Hourly urinary specimens were collected at 0930, 1030, 1130, and 1230. The volume and specific gravity of each was measured.

9. The subject was allowed to be ambulatory during the test and regularly ate lunch at 1200. Some of the men went to church or met other appointments; the majority, however, either remained

in bed or stayed in the ward reading or playing cards. In general, a given individual engaged in the same type of activity during the several test-days.

Calculations: The ability of the kidney to concentrate, as well as dilute, urine was judged by a comparison between the specific gravities of the 2230-0730 urinary specimen, and the hourly specimens collected after the oral load had been given. To calculate the percent of the load given which was excreted in four hours, the following formula was used:

$$\% \text{ load excreted} = \frac{V_1 + V_2 + V_3 + V_4 - 4 \times \text{basal volume}}{20 \text{ ml/kg} \times \text{body weight}} \times 100$$

where V_1, V_2, V_3 and V_4 are the volumes of the four hourly post-load specimens.

Interpretation: The conventional interpretation of the results is that Addison's disease may be suspected when the volume of the 2230-0730 urinary specimen exceeds the maximum post-load urinary volume. It is obvious, however, that the response of the subject to this test will be largely conditioned by his degree of hydration. A dehydrated individual may retain all of the water given him so that his "night" urine volume would greatly exceed the maximal post-load volume. We repeatedly found this situation to occur in our subjects on limited water. Additional investigation is underway to study this water diuresis test as a measure of body hydration.

3. Body Fat

Three methods of indirectly estimating body fat were used: (1) calculation from data on the skin-fold thickness, (2) calculation from the measurement of total body water (antipyrine and D_2O spaces), and (3) somatotyping. The reliability of these various devices has been recently reviewed by Brozek and Keys (1950), Keys and Brozek (1953), and Keys (1953).

Skin-fold Thickness. Measurement of the thickness of skin-folds at selected sites on the body has been shown to correlate, to a highly significant degree, with the body fat as measured by the specific gravity method (Brozek and Keys, 1951). For this reason the former, and simpler, procedure has been proposed as a useful device for metabolic and nutritional investigation. Our experience and that of others (Keys and Brozek, 1953), however, indicate that much additional study will be required before the procedure will yield reliable, comparable, and interpretable data. The chief problems fall into two groups: (1) development of reliable calipers for measuring skin-fold thickness and standardization of methods of measurement and (2) elucidation of conditions other than changes in body fat which influence interpretation of measurements.

STAT

Method: In the investigation the vernier calipers developed by the Laboratory of Physiological Hygiene, University of Minnesota, were employed. These calipers have been described by Brozek (1952). The arm, chest, and abdominal sites recommended by Brozek and Keys (1951) were selected for routine measurement; and the nomograms, prepared by Best (1953) from the regression equations of Brozek and Keys (1951), were used to calculate the percent of body fat. Single measurements were made during the "two-hour" test with the subject reclining. Approximately the same sites were used at each measurement, and as closely as possible the technique of Brozek and Keys (1951) and Brozek (1952) was followed. The calipers were read to the nearest 0.1 mm, the percent of body fat was calculated to the nearest 0.1%, and the kg of body fat to the nearest 0.1 kg. Weight on day of measurement (kg) times percent of body fat equals kg of body fat.

Validation: The technical problems involved in obtaining consistent data on skin-fold thickness have been reviewed by Keys and Brozek (1953). Data are cited which represent the consistency of measurements made by two independent observers on 76 normal young men:

	% Body Fat
Observer 1	12.4 ± 5.6
Observer 2	12.4 ± 5.6
r_{12}	0.996

Thus, the data obtained by two observers was highly and significantly intercorrelated. Similarly high correlations were made when repeated measurements were made on the same individual.

We obtained other data in this study which bear on the consistency of measurements on normal young men. The problem was to determine how reliable the measurements were when a subject was measured once a week at weekly intervals. The best answer to this question could be obtained when the subject maintained a constant caloric intake, a constant body weight, and a normal degree of hydration. Such data are summarized in Table II. 17 for subject 5. During the pre-period and the two subsequent experimental periods, his caloric intake remained close to 3000 Cal/day and his daily body weight averaged 66.5 ± 0.4 kg. The percent of body fat and the absolute body fat varied 0.4 % and 0.3 kg, respectively. Subject 6 was on the same regimen, but he had limited water for five days. His caloric intake was approximately 3000 Cal/day and except for the five days of dehydration, his body weight averaged 64.5 ± 0.4 kg. Closely reproducible data were obtained in two measurements made when this subject was adequately hydrated. During the five days of limited water he lost weight (3.0 kg), and

TABLE II. 17

CRITIQUE OF MEASUREMENT OF BODY FAT BY SKIN-FOLD THICKNESS TECHNIQUE

Subject and Period	Caloric Intake	Fluid Intake	Body Weight	Body Fat	
	Cal/day	l/day	kg	%	kg
Subject 5					
Pre-Period	3091	1.76	66.6	8.6	5.7
Exper. I	2972	2.19	65.9	8.2	5.4
Exper. II	3003	1.99	66.4	8.2	5.4
Subject 6					
Pre-Period	2804	1.34	64.6	5.8	3.7
Exper. I	2963	0.60	61.6	6.9a	4.3a
Exper. II	3000	2.32	64.1	5.7	3.7

aInterpretation. During periods of unlimited water these data confirm those of Subject 5. However, during the period of limited water (Subject 6, Experimental I), the calculation of body fat from skin-fold thicknesses led to the obviously erroneous conclusion that there was an increase in body fat during dehydration.

calculation of body fat from the skin-fold measurements indicated an increase, both relative and absolute. This conclusion is obviously erroneous and suggests that dehydration is a condition which invalidated the equations of Brozek and Keys (1951). Exposure of the unacclimatized man to heat will also cause an apparent increase in the percent of body fat; peripheral vasodilatation or subcutaneous edema may have caused the increase in the skin-fold thickness (Keys and Brozek, 1953). The problem of dehydration and estimation of body fat will be discussed more fully in the section on Body Composition (Results).

Calculation from Total Body Water. On the basis of detailed chemical analyses of 50 guinea pigs, Pace and Rathburn (1945) have suggested that percent of body fat can be calculated from the equation:

$$\% \text{ body fat} = 100 - \frac{\% \text{ body water}}{0.732}$$

Although this equation or ones quite comparable in form have been widely used, they have not been fully validated and the effects of errors (analytical and systematic) and assumptions involved have not been adequately defined and explored. Keys and Brozek (1953) have critically examined these problems and their review is recommended for a full appreciation of the limitations involved in the application of such equations as that proposed by Pace and Rathburn. For want of a better equation, the one above was used in a study of

STAT
STAT

the effect of the nutrient mixtures.

Somatotyping. At biweekly intervals the subjects were photographed in profile and anteriorly-posteriorly against a grid after the method of Sheldon (1940). There is a significant correlation between body type (endomorph, mesomorph, ectomorph) and specific gravity (Keys and Brozek, 1953). It was felt that it would be of interest to examine this relationship in so far as the present data were concerned. These data have not been analyzed.

4. Lean Body Mass

The term "lean body mass" is coming into increasingly wide usage in clinical investigation. Since there is no way of measuring lean body mass directly, it is very important that a precise definition be given. Lean body mass, according to the assumptions made, can be calculated in a number of ways. Lean body mass has been called one of the physiological constants and it has been suggested by a number of investigators that measurements be expressed per unit weight of lean body mass rather than per kg of body weight or square meter of surface area. Vague usage and unvalidated assumptions have made the whole area confusing, complex, and controversial. This field has been liberally explored by mathematically inclined clinical investigators and formulae are abundantly available. None of the formulae, in spite of their statistical validity, are any more valid than the basic assumptions made in developing the equations. Furthermore such formulae cannot be freely used under conditions other than those described by the original basic assumptions. Because of the vagaries of this area, we have made only limited use of such empirical relationships.

The underlying hypothesis has recently been stated by Keys and Brozek (1953, p. 281): "The concept of a basic substance, protoplasm, which is common to all living cells, suggests a basic composition of water salts, salts and protein so that the animal body would be composed of this vital material, of substantially fixed composition, plus skeletal structures and variable amounts of fat." The fat-free body thus has a fixed composition. The lean body mass thus might be defined as the fat-free body weight (Keys, 1953). Although it is a simple matter to measure the gross body weight, we have already indicated that measurement of body fat is not simple and data cannot at present be accepted on their face value. Certainly, as defined, the lean body mass includes not only metabolically active tissue, but such relatively inert substances as water (extracellular fluid) and supporting structures such as cartilage, tendons, and bones. One measure of "active tissue" is lean body mass less extracellular fluid less skeletal mass (Keys, 1953). In order to study changes in the mass of active tissue or lean tissue, we must make the assumption that the tissue is constant in composition. We must further assume what that constant composition is. The general tendency is to assume that

most of the active tissue or lean body mass is muscle and the constant composition is the composition of muscle (Reifenstein et al., 1945). Homburger et al. (1952) emphasize that it is erroneous to assume that "protoplasm" has the same composition as muscle and that muscle constitutes most of the body "protoplasm." If the body weight changes, it is possible to calculate on the basis of metabolic balance data, the contribution to the change from lean body mass, extracellular fluid, and fat (Reifenstein et al. 1945). These calculations are derived from theoretical balances, - the balance of one substance expected from the balance of others. To calculate theoretical balances one must use certain ratios which depend upon the assumptions that the ratios are constant and characteristic of the active tissue. Reifenstein et al. (1945), for example, assume that the N/P ratio for protoplasm is that for muscle = 14.7. The validity of such metabolic patterns depends upon the constancy of these ratios. That they are not constant, limits the usefulness of theoretical balances and requires great caution in their application to metabolic investigation (Homburger et al., 1952). Examination of the data collected during the present studies supports the critical analysis of the problem by Homburger et al. (1952). These data will be discussed in detail in another section of this report.

Definitions and Calculations (Keys, 1953; Homburger et al., 1952).

Lean body mass = gross body weight - body fat.

P output accountable by Ca = $\frac{\text{mg Ca excreted}}{2.23}$

Net P output = gross P output - P accountable by Ca.

N/P ratio = nitrogen output/net phosphorus output

Theoretical nitrogen balance = 15.0 x net phosphorus balance

K. CLINICAL OBSERVATIONS AND METHODS

Candidates for subjects were interviewed by a medical officer at which time a detailed medical and surgical history was obtained and a complete physical examination was conducted. These examinations were conducted in November 1952. When the investigation proper began in January, 1953 the subjects selected were given complete physical examinations again. Physical examinations were repeated regularly thereafter at the end of each pre-period and the end of each experimental period. Whenever the subjects became ill for reasons attributable to the diets or otherwise, examinations were made. If the subjects had to be removed from experimental diets early, they were examined within 24 hours after ending the

STAT
STAT

regimen. All physical examinations conducted from January to June were made by the same medical officer (F.S.) in order to provide uniformity of examination and interpretation of signs. In all instances the examinations were conducted according to the standard techniques of physical diagnosis (Pullen, 1944). Relevant histories were obtained also on these occasions.

Daily progress notes were maintained by the medical officer on each subject. These notes documented both spontaneous and elicited complaints with reference to the health and well-being, physical and psychological, of the subjects, together with observations of the medical officer on the condition of the subjects individually or as a group.

Two local physicians were briefed regarding the purpose and plan of the experiment and agreed to be on call in the event of an emergency.

Medication given the subjects was kept at an absolute minimum. Aspirin was used sparingly (not more than 20 grains per day) for headaches, aspergum for sore throats. One subject was given a brief course of aureomycin for an acute upper respiratory infection. Diarrhea was controlled with paregoric or kaopectinate. One subject was allowed to take benzidrine during a recovery period while studying for a final examination. Details on medication for individual subjects are reported in the Case Histories (Appendix IV).

Diagnostic procedures were employed when indicated. Routine PA-chest plates and E.K.G.'s were taken during the selection of the subjects. These procedures were repeated at the end of the study. All these X-rays and E.K.G.'s were read by specialists on the staff of 3345th Medical Group at Chanute Air Force Base. One gall bladder series and two gastrointestinal studies were performed in cooperation with the local physicians.

L. COMBINED TESTS

Because of the limited time available for conducting functional and metabolic tests, an attempt was made to devise combinations of such individual procedures so that a great deal of information could be obtained within the least possible time. Two combined tests were developed and successfully used throughout this investigation: (1) organic function - resting metabolism test and (2) test of reaction to stress.

1. Organic Function - Resting Metabolism Test

The protocol for this test is detailed in Table II. 18. The procedure followed and analyses and calculations made on the data collected are shown. In the jargon of the test-team this particular

PROTOCOL OF ORGANIC FUNCTION-RESTING METABOLISM TEST

PROCEDURE	ANALYSES AND CALCULATIONS
1. Drink 100-200 ml. of water. 2. Void into 24-hour spec. bottle, note time. 3. Weigh on Sanctorius balance; note time. 4. Recline 30 minutes. 5. Measure: oral temp., pulse, B.P., skinfold thickness, passage of time, last 10 min. 6. Ten-minute collection of expired air in Tissot gasometer. 7. Measure W B T. and D B.T. 8. Weigh on Sanctorius balance; note time. 9. Venipuncture; note time. (Lapsed time 60 min.) 10. Mix expired air, record vol., temp., and barometric pressure; collect sample in 50 ml. oiled syringe. 11. Void at ± 120 min. into special specimen bottle; note time. 12. Measure urinary vol.; save 25 ml. aliquot in special spec. bottle.	A. LIVER FUNCTION 1. Two hr. urobilinogen 2. Ceph. alin floc. B. RENAL FUNCTION 1. 24 hr. urine vol. 2. Addis count. 3. Creatinine clearance. 4. Free NH_3. C. CARDIOVASC. FUNCTION 1. B.P. 2. Pulse D. PSYCHIC FUNCTION 1. Passage of time E. BODY COMPOSITION 1. % Body fat 2. Lean body mass F. METABOLISM 1. O_2 consumption 2. R.Q. 3. Pulmonary vent. 4. Insensible H_2O loss G. HEMATOLOGY 1. R.B.C. 2. W.B.C. 3. Differential 4. Eosinophil count 5. Hemoglobin 6. Hematocrit 7. Sed. rate. 8. Platelet count

TABLE II. 18

STAT
STAT

regimen. All physical examinations conducted from January to June were made by the same medical officer (F.S.) in order to provide uniformity of examination and interpretation of signs. In all instances the examinations were conducted according to the standard techniques of physical diagnosis (Bullen, 1944). Relevant histories were obtained also on these occasions.

Daily progress notes were maintained by the medical officer on each subject. These notes documented both spontaneous and elicited complaints with reference to the health and well-being, physical and psychological, of the subjects, together with observations of the medical officer on the condition of the subjects individually or as a group.

Two local physicians were briefed regarding the purpose and plan of the experiment and agreed to be on call in the event of an emergency.

Medication given the subjects was kept at an absolute minimum. Aspirin was used sparingly (not more than 20 grains per day) for headaches, aspergum for sore throats. One subject was given a brief course of aureomycin for an acute upper respiratory infection. Diarrhea was controlled with paregoric or Kaopectinate. One subject was allowed to take benzidrine during a recovery period while studying for a final examination. Details on medication for individual subjects are reported in the Case Histories (Appendix IV).

Diagnostic procedures were employed when indicated. Routine PA-chest plates and E.K.G.'s were taken during the selection of the subjects. Those procedures were repeated at the end of the study. All these X-rays and E.K.G.'s were read by specialists on the staff of 3345th Medical Group at Chanute Air Force Base. One gall bladder series and two gastrointestinal studies were performed in cooperation with the local physicians.

L. COMBINED TESTS

Because of the limited time available for conducting functional and metabolic tests, an attempt was made to devise combinations of such individual procedures so that a great deal of information could be obtained within the least possible time. Two combined tests were developed and successfully used throughout this investigation: (1) organic function - resting metabolism test and (2) test of reaction to stress.

1. Organic Function - Resting Metabolism Test

The protocol for this test is detailed in Table II. 18. The procedure followed and analyses and calculations made on the data collected are shown. In the jargon of the test-team this particular

PROTOCOL OF ORGANIC FUNCTION-RESTING METABOLISM TEST

PROCEDURE	ANALYSES AND CALCULATIONS
1. Drink 100-200 ml. of water 2. Void into 24-hour spec. bottle, note time. 3. Weigh on Sanctorius balance; note time. 4. Recline 30 minutes. 5. Measure oral temp., pulse, B.P., skinfold thickness, passage of time; last 10 min. 6. Ten minute collection of expired air in Tissot gasometer. 7. Measure W B T and D B T 8. Weigh on Sanctorius balance; note time 9. Venipuncture, note time. (Lapsed time 60 min.) 10. Mix aspired air, record vol., temp. and barometric pressure; collect sample in 50 ml. oiled syringe. 11. Void at c. 120 min. into special specimen bottle; note time. 12. Measure urinary vol.; save 25 ml. aliquot in special spec. bottle	A. LIVER FUNCTION 1. Two hr urobilinogen 2. Ce. rain floc. B. RENAL FUNCTION 1. M'n urine vol. 2. Addis count 3. Creatinine clearance 4. Free NH3 C. CARDIOVASC. FUNCTION 1. B P. 2. Pulse D PSYCHIC FUNCTION 1. Passage of time E BODY COMPOSITION 1. % Body fat 2. Lean body mass F METABOLISM 1. O_2 consumption 2. R.Q. 3. Pulmonary vent 4. Insensible H_2O loss. G. HEMATOLOGY 1. R.B.C. 2. W.B.C. 3. Differential 4. Eosinophil count 5. Hemoglobin 6. Hematocrit 7. Sed. rate 8. Platelet count

TABLE II. 18

combination of tests was called the "two-hour" test. It will be so labelled throughout this report.

Comments on the Procedure. All the subjects were tested in an operating room equipped with a humidifier. Within this room it was possible to maintain a reasonably constant ambient environment of about 25-30°C and 50-60% relative humidity. Prior to entering this room the subjects drank a small volume of water to insure adequate urine flow two hours later and then voided. In the room they stripped to underpants and followed through steps 3-9. After the venipuncture the subjects were given a special bottle and told to void into it at a known time approximately two hours after the initial voiding. They were allowed to be ambient during the second hour.

All data collected during the test have been defined as "resting" data. At the time of the test the subjects were not postabsorptive but postcibal. For each subject the test was conducted once a week at a regularly scheduled time. In general the two-hour test was conducted in the mornings on days 4 and 5 of each week. If a subject was taken off one of the regimens early, the "two-test" was run at the subject's regular time the day before recovery commenced.

The details of the several procedures employed in this combination have been given in appropriate sections above together with comments on their validation and reproducibility; the calculations made, and their interpretation. (See Clinical Pathology, Liver Function, Renal Function, Respiratory Function, Cardiovascular Function, Central Nervous System, and Body Composition.)

2. Exercise Stress In Assessment Of Autonomic Function

Few methods have been described in the literature for assessing the functional capacity of the autonomic nervous system. Of the work reported much is by Wenger and his colleagues, (Wenger and Ellington, 1943; Wenger, 1942, 1943abc) in which many simultaneous independent measurements were made on structures whose activity was conditioned by the activity of the autonomic nervous system. By means of factorial analysis, these investigators have attempted to arrive at an empirical value of autonomic balance.

The "normative regression equation of autonomic balance" as determined by Wenger and Ellington (1943) is:

$$\bar{A} = .1_{23T} + .2_{25T} + .4_{28T} + .3_{37_xT} + .1_{39_xT} + .1_{57T} + .2_{80T}$$

where $\bar{A}$ is the estimated score for the autonomic balance and the subscript numbers and the letter T indicate the standard scores for the seven tests of the battery. The "x" following subscripts "37" and "39" indicates that the scores of these two tests are to be reversed in direction. This operation has been performed in tables published by Wenger and Ellington (1943). The battery of tests selected from the many studied included persistence of red dermographia (23), salivary output (25), heart period (28), standing palmar skin conductance (37), volar skin conductance (39), respiration period (57), and pulse pressure (80). (Numbers in parentheses are subscripts in the equation above.)

High scores of autonomic balance are regarded as representing a predominant activity of the parasympathetic division of the autonomic nervous system, low scores, a predominant activity of the sympathetic division (Wenger and Ellington, 1943). It has been shown by Wenger (1943c) that in general individuals who have low scores in winter have higher scores in summer, while those with high scores in winter tend to have lower scores in summer. To our knowledge these claims and the use of this battery of tests to measure "autonomic balance" have neither been confirmed nor denied by other investigators.

Test Protocol. Inasmuch as the activity of the structures measured by these investigators is dependent upon a variety of factors other than the activity of the autonomic nervous system, it was decided to attempt devising a method whereby the activity of the autonomic nervous system could be assessed more directly. The protocol shown in Table II. 19 was adopted.

Basis for Selection of Tests. Our hypothesis was based on the fact that the activity of the autonomic nervous system could be measured adequately only after the subject was exposed to a standard stress. A stress which could easily be controlled was exercise. Therefore, it was chosen. Although many of the procedures had not been used on the human subject previously, it was believed that, for any direct assessment of the function of the autonomic nervous system, one should measure functions which were influenced (1) solely by the sympathetic division of the autonomic nervous system, (2) solely by the parasympathetic division and (3) influenced by a joint action of both sympathetic and parasympathetic division. This hypothesis served as the basis for selecting the battery of tests detailed in Table II. 19.

Since the medulla of the adrenal gland is innervated solely by the sympathetic division, and since the activity of the medulla is the result of nervous stimulation, it was decided that measurement of the amount of circulating adrenaline could be used as a measure of activity of the sympathetic nervous system.

The work of Myerson (1938) demonstrated that the electrical conduction time along the Bundle of His was influenced only by acetylcholine. It was therefore decided that measurement of the PR interval from an electrocardiogram might provide a direct

TABLE II. 19

PROTOCOL FOR ASSESSING FUNCTIONAL ACTIVITY OF THE AUTONOMIC NERVOUS SYSTEM

I. Subject rests on bed 10 minutes
   A. During first 5 minutes prepare subject for testing
   B. During second 5 minutes measure:
      1. Pupil size (photographically)
      2. Electrocardiogram
      3. Blood pressure
      4. Skin temperature (right nipple, scapula and wrist)
      5. Draw blood for determination of:
         a. Glucose
         b. Eosinophil count
         c. White blood cell count and differential
         d. Adrenaline
      6. Circulation time (Lange and Boyd, 1942)

II. Subject performs passive exercise on Kinocycle (Kinocycle Co.) for 10 minutes at a speed setting of #10, pedal position #4 of the Kinocycle used
   A. During last 3 minutes of exercise collect expired gas in Tissot tank

III. Subject rests on Kinocycle for 10 minutes
   A. Measure volume of expired gas
   B. Record gas temperature
   C. Record barometric pressure
   D. Record wet and dry bulb temperatures
   E. Collect 50-ml sample of expired air in oiled syringe

IV. Subject performs voluntary exercise on Kinocycle for 10 minutes with metronome setting of 160/min, pedal position #4, weight at position #6. (Subject moves flywheel 1/2 revolution for each metronome count)
   A. Record pulse rate at 3 and 7 minutes after beginning of exercise

V. Subject again rests on bed
   A. During first five minutes of rest measure:
      1. Pupil size (photographically)
      2. Electrocardiogram
      3. Blood pressure (approximately 5 minutes after exercise ends)
      4. Skin temperature (right nipple, scapula and wrist)
   B. Record blood pressure (10 minutes after end of exercise)
   C. Draw blood sample 60 minutes after end of exercise
      for determination of:
      1. Glucose
      2. Eosinophil count
      3. White blood cell count and differential
      4. Adrenaline
   D. Draw blood sample 120 minutes after end of exercise for determination of:
      1. Glucose
      2. White blood cell count and differential
      3. Eosinophil count
      4. Adrenaline

measurement of parasympathetic activity.

The photographic measurement of the diameter of the pupil was chosen as a means of measuring the effects of interaction between the parasympathetic and sympathetic divisions of the autonomic nervous system (Ryerson, 1939; Hartman and Brownell, 1949).

For comparison of data collected during these tests with published data, several measurements were made of functions, which, although not specifically influenced by the autonomic nervous system, are at least modified by autonomic nervous activity. These included blood pressure (Dill and Bock, 1931), skin temperature (Newburgh, 1940), blood glucose (Dill and Bock, 1931), eosinophil count and heart rate (Dill and Bock, 1931). The total white blood cell count was made in order to interpret the changes which might occur in the eosinophil count. The differential was studied as a matter of interest.

Other Measurements. The circulation time was measured by the fluorescein technic of Lange and Boyd (1942) while the subject was resting (although not necessarily postabsorptive) as part of the assessment of cardiovascular function. Expired gas was collected and analyzed according to standard procedures (Consolazio, Johnson, and Marek, 1951). The data were used (1) to measure the metabolic rate during passive exercise and (2) to compare metabolic mixtures (Hawk, Oser and Summerson, 1951) of resting and passive work.

Physiological Measurements.

Skin temperature: Leeds and Northrup portable potentiometer calibrated to read directly in °C. The instrument was internally standardized before every day of use.

Blood pressure: Mercurial Baumanometer; auscultation.

Electrocardiogram: Sanborn portable electrocardiograph. Pulse and P-I interval calculated from record. Pulse during work counted by palpation.

STAT
STAT

Pupil size: Subject was lying on the bed, illuminated with blood lamps which were standardized in position, camera setting was adjusted according to a General Electric light meter. The camera used was a Kinepacta model II. Under the photographic conditions it was not possible to measure accurately changes in the diameter of pupil in those individuals having dark irides. It is felt use of a telescopic lens would remedy this condition. Since most of the subjects had dark irides, no data on pupil size will be presented in this report.

Circulation Time (Lange and Boyd, 1942).

Expired Gas (Consolazio, Johnson and Marek, 1951). See section on Respiratory Function.

Blood Measurements.

Blood glucose: See section on Clinical Chemistry.

Direct eosinophil count, differential, and total white blood count: See section on Hematology.

Blood adrenaline: An attempt was made to measure blood adrenaline by the method of Raab (1943). It proved impossible to validate this method and to obtain reproducible standard curves. Considerable effort was expended to discover the sources of the unreliability. It was finally concluded that the chemical conditions were so inadequately controlled and detailed that further research in this direction would be required before trustworthy results would obtain. Furthermore, a survey of the literature failed to reveal any other method which seemed more reliable - other than bioassay. Bioassay was not attempted because of the limited time available for standardizing a new procedure.

Condition of Subject Prior to Test. The subjects were tested under as standard conditions as possible. Due to their academic schedules it was not possible to have them postabsorptive. For any given subject the test was carried out first during the pre-period and again during the second week of the succeeding experimental period. On both occasions the subject was tested at the same time of day; i.e., at approximately the same number of hours following a meal.

Training did not play a role in these tests. The several subjects were not used in every phase of the experiment. Time permitted testing only in every other phase. Because there was no regular required exercise during the five months of the study and because the subjects were tested relatively infrequently under the conditions of the exercise-stress, there was no opportunity for the systematic physiological changes of training to develop (Dill and Bock, 1931).

M. STATISTICAL METHODS

1. The Concept of Own-Control

The design of the present investigation was that common to all clinical investigation; viz., repetition of critical observations on the subject in a pre-period, an experimental period, and a recovery period. This device might be identified as the concept of "own-control." Each subject serves as his own control in that the influence of the experimental regimen on the critical observations can be assessed by comparing the data of the experimental period with those of the pre-period and recovery period. By this device the measurements of the pre-period can arbitrarily be equated to 100 and the data of the experimental and recovery periods expressed as a percentage of the pre-period measurement. The results of the several critical observations are thus expressed in units independent of the original observations and the order of magnitude of deviations from the pre-period or control values becomes readily apparent.

It is a known fact that individuals differ one from another with respect to the exact value of a given physiological or biochemical measurement. This inter-individual variability --- the so-called normal range --- may prejudice statistical analyses when absolute values are used in the mathematical treatment. On the other hand, the concept of own-control allows this potential bias to be minimized. When the individual control data are set equal to 100, the changes in the experimental and recovery periods can be expressed as averages which are not prejudiced by the influences of one individual. This mathematical procedure was used in studying the effects of the several experimental nutrient mixtures on a great many of the functions of organs and systems and different biochemical levels in the several biological fluids.

2. The Concept of Positive and Negative Control

The philosophical aspects of positive and negative control have been considered above in the section on Dietetics and Nutrient Mixture. Here we wish to emphasize the statistical implications of these controls. Positive and negative control can be visualized as the upper and lower limits of variation in physiological processes and biochemical levels in this investigation. Generally speaking, positive control was the optimum nutrient mixture. It should follow then that a measurement expressed as a percentage of the pre-period average should remain, within the limits of experimental error, at 100% in the experimental and recovery periods. The maximum deviation, plus or minus, from 100% should occur in negative control. The other nutrient mixtures should give values within the limits described by positive control and negative control. The differences between the measurements made during the 1000- and 2000-calorie regimens and those made in the control regimens can be

STAT
STAT

evaluated statistically and assist in drawing conclusions regarding the best possible nutrient mixture for survival. This attitude of mind has been adopted in this investigation in the analysis of the entire body of observational material.

Definition and Description of Statistical Methods

Throughout this report the statistical methods and terms are the same as those detailed in Rider's (1939) Statistical Methods.

Average and mean are used interchangably and in both cases refer to the arithmetical mean.

The variance of a set of data from the mean has been measured in two ways: (1) standard deviation and (2) coefficient of variation. The standard deviation has been calculated from the equation:

$$\sigma^2 = \frac{1}{N} \sum (x-\bar{x})^2$$

where σ = standard deviation. The coefficient of variation was calculated from the equation:

$$C.V. = \frac{\sigma}{M} \times 100$$

where C.V. = coefficient of variation and M = arithmetical mean.

The "t" test and analysis of variance followed the formulae given in Rider (1939).

3. Validation of Methods

Most of the procedures used in this investigation were validated in the hands of the individual responsible for the particular method. In some instances, validation was rather elaborate. Such experiments have been detailed in appropriate sections above. In the case of all chemical methods, recovery studies were performed. In general ten recovery experiments were done before results were accepted as satisfactory. In all such cases the material recovered was 95-105% of that added. Where recovery experiments were not possible, as in the case of hematology, single bloods or urines were analyzed 10-12 times so that a standard deviation and coefficient of variation could be calculated. The measures of variance gave us an estimate of the technical error involved in the analysis. Some of the hematological data are summarized in Table II.-20.

TABLE II. 20

HEMATOLOGY: VALIDATION OF METHODS

Measurement	Mean	σ	C.V.
			%
White blood cells/mm^3	6,925	480	6.9
Red blood cells, mill/mm^3	6.26	0.69	11.0
Differential			
1. Lymphocytes, %	22.1	1.8	8.1
2. Neutrophiles, %	62.8	1.7	2.7
3. Segmented forms, %	57.4	1.9	3.3
4. Bands, %	5.4	1.4	25.9
5. Monocytes, %	2.7	1.2	44.4
6. Eosinophils, %	1.1	0.6	54.6
7. Basophils, %	0.2	0.7	350.0
Eosinophils/mm^3	46.4	14.8	31.2
Prothrombin Time, sec	13.2	0.2	1.5
Sedimentation rate, mm/hr	4.5	0.5	11.1
Hematocrit, %	50.1	0.5	1.0
Platelets/mm^3	304,600	445	0.1

4. Discussion of the Handling of Aliquots of Urine for the Calculation of Mean Daily Excretions

The routine of handling the many daily specimens of urine was set up to minimize labor, to minimize errors, to facilitate the work of the analysts and to simplify calculations as much as possible. In pursuit of these ends, the daily urine specimen was diluted to 2000 ml and an aliquot of 300 ml was added to the weekly pool. At the end of the six days, the 1.8 liters of urine (6 days x 300 ml aliquot per day), was mixed and analyzed.

In previous studies, it has been only a rare occurrence that any daily volume was more than two liters. After it was too late to change the protocol, the methods and the notebooks, it turned out that one subject (No. 7) consistently produced more than two liters of urine per day; he liked to drink cups of coffee at frequent intervals. Therefore, it proved necessary to devise a method of calculation for conditions when the daily volume was more than the routine 2000 ml to which all specimens were supposed to be diluted. A mathematical analysis of this problem is presented below.

When All Daily Volumes Were Less Than Two Liters. Under all circumstances, the basic equation is:

$$S = (V_1C_1 + V_2C_2 + \ldots\ldots V_6C_6)/6 \qquad \text{(Eq. 1)}$$

where V_1, V_2.....V_6 is urine volume, in liters, for day 1, 2,....6; C_1, C_2.....C_6 is the concentration of the substance per liter; and S is the mean daily excretion of the substance in question.

In the present case, V_1, V_2.....V_6 were all diluted to 2000 ml, and a mean concentration based on the diluted specimens was determined. Therefore, Equation 1 simplified to:

$$S = C_m(6 \times 2)/6 = 2C_m \qquad \text{(Eq. 2)}$$

when S is the mean daily excretion; and C_m is the concentration per liter of the pooled, diluted urine.

When Some or All of the Daily Urine Volumes Are Greater Than Two Liters. Under these particular circumstances, the urine was not diluted further if it was greater than 2 l; at the same time an aliquot of 300 ml was taken routinely for the weekly pool. Starting again with Equation 1,

$$S = (V_1C_1 + V_2C_2 \ldots\ldots V_6C_6)/6 \qquad \text{(Eq. 1)}$$

The approximation actually arrived at was:

$$S = (C_m) \times \left(\frac{3}{1/V_1 + 1/V_2 + \ldots\ldots 1/V_6}\right) \times (2) \qquad \text{(Eq. 3)}$$

where S is mean daily excretion; C_m is concentration per liter in the mixed pool of 0.3 l daily aliquots; and V_1, V_2.....V_6 are the daily urine volumes in liters, 2 if the urine volume had been diluted and the actual volume if the volume was over 2 l.

This approximation is not a rigorously true equation. However, it has been shown to be approximately correct empirically, inasmuch as the relations among volume and concentration are such that day to day errors tend to cancel out, and not to summate. It is arrived at by the following considerations:

(1) When all the daily volumes have been diluted to 2 l, originally having been less than 2 l, Eq. 3 reduces to Eq. 1 and is precisely accurate.

(2) When a daily volume was greater than 2 l, it could not have been diluted to 2 l. At the same time, 0.3 l was taken as an aliquot. This 0.3 l, in relation to those samples taken from a 2 l dilution, was actually equivalent to the fraction $\frac{(0.3) \times (2/V)}{2}$ of the daily urine instead of $\frac{(0.3) \times (2/2)}{2}$, as in the usual case.

Now, over a period of 6 days, the daily pools actually added were 6 x 0.3 l, and these represented the "effective" amount 0.3 x $2/V_1$ 0.3 x $2/V_2$ ..... 0.3 x $2/V_6$, and the corrected ratio of actual aliquots to "effective" aliquots is therefore

$$\frac{6 \times 0.3}{(0.3) \times (2) \times (1/V_1 + 1/V_2 + \ldots\ldots 1/V_3)} = \frac{3}{(1/V_1 + 1/V_2 + \ldots\ldots 1/V_6)}$$

When some or all of the V's are over 2, this ratio is > 1; when all are diluted up to 2, the ratio is precisely 1.

(3) A hidden assumption is made that the C_m arrived at by analysis is valid under these circumstances as representing the mean of the actual $C_1 + C_2 + \ldots\ldots C_6$. Empirically, this assumption is valid, as has been shown for creatinine and total osmotic pressure.

(4) The approximation has been checked with respect to creatinine, as is shown in Table III. 21.

TABLE II. 21

APPROXIMATION FOR CREATININE, DAILY URINE VOLUMES OVER TWO LITERS

Date	Creatinine gm/day	Urine Volume l/day	Creatinine gm/l
April 24	2.74	2.360	1.16
April 10	1.76	2.520	0.70
April 17	2.45	2.750	0.89
Feb. 26	2.81	2.200	1.28
Jan. 23	2.26	2.140	1.06
March 20	3.50	4.670	0.75
	15.52	16.640	5.84
Mean	2.59	2.773	0.975

a) True mean excretion = 2.59 gm/day
b) Mean concentration of aliquots = 0.975 gm/l
c) Use of present approximation
Estimated mean excretion =

$$(0.975) \times \left(\frac{3}{1/2.36 + 1/2.52 + 1/2.75 + 1/2.2 + 1/2.14 + 1/4.67}\right) \times 2$$

$$= (0.975) \times (3/2.320) \times (2)$$

$$= 2.53 \text{ gm/day}$$

d) The error between "true" and "calculated" is 2.3%.

STAT

In this particular case, the error between "true" and "approximated" values was 2.3%. In four other similar sets of calculations, the range of error was from 0.3 to 4.2%. It is concluded that for creatinine, and probably other nitrogenous constituents, the approximation is empirically valid within usable limits.

(5) With respect to total solids, the approximation has been checked with osmotic pressure when the volumes were greater than 2 liters per day, as shown in Table II. 22.

TABLE II. 22

APPROXIMATION FOR TOTAL OSMOTIC PRESSURE WHEN DAILY URINE VOLUMES ARE GREATER THAN TWO LITERS

Date	Osmotic Effect	Urine Volume	Osmotic Concentration
	Osm/day	l/day	Osm/l
May 4	1.51	2.070	0.73
May 7	1.94	2.515	0.77
May 8	1.54	2.405	0.64
May 6	1.41	2.350	0.60
Apr. 28	1.72	2.355	0.73
Apr. 29	1.51	2.480	0.61
	9.63	14.175	4.08
Mean	1.605	2.363	0.68

a) True values: mean osmotic effect = 1.605 Osm/day
b) Mean osmotic pressure of aliquots = 0.68 Osm/l
c) Use of present approximation
Estimated mean excretion =

$$(0.68) \times \left(\frac{3}{1/2.07 + 1/2.515 + 1/2.405 + 1/2.350 + 1/2.355 + 1/2.480} \right) \times (2)$$

$$= (0.68) \times (3/2.551) \times (2)$$

$$= 1.600 \text{ Osm/day}$$

d) % error $= \frac{(1.605 - 1.600)}{1.605} \times 100 = 0.3\%$

It is seen that the approximation is within 0.3% of the true value. Now, osmotic pressure takes into account all the solutes in the urine, and we conclude that for the purposes of the present experiment, the approximation is valid to a sufficient degree of accuracy.

N. SUMMARY TABLE OF METHODS AND NORMAL RANGES

In order to facilitate analysis and study of the observations reported and discussed in Sections III and IV of this report, tables of expected values for all the measurements made in this investigation have been culled from the literature and summarized in Table II. 23. In most cases the normal ranges have been given. The normal range is defined as the spread of values within which would be expected to fall a particular observation made on a human being free of clinically demonstrable disease, under specified conditions of diet, exercise, and temperature. The normal ranges have been established by manifold observations on randomly selected individuals. When sex or age influences the normal range, that applicable to healthy young males has been given in Table II. 23. Where normal ranges per se have not been readily available, the mean standard deviation or an indication of the order of magnitude to be expected have been noted.

TABLE II. 23A

NORMAL RANGES: WHOLE BLOOD

Substance Measured	Units	Range	References
Ascorbic Acid	mg/100 ml	0.1-2.5	1
Differential	%, total WBC		
Neutrophils	%, total WBC	37-75	1
Lymphocytes	%, total WBC	25-33	9
Monocytes	%, total WBC	3-7	9
Eosinophils	%, total WBC	1-3	9
Basophils	%, total WBC	0-1	9
Direct Eosinophil Count	cells/mm^3	30-250	2
Glucose	mg/100 ml	70.0-110.0	6
Hematocrit	ml/100 ml	40.0-54.0	1
Hemoglobin (Hb)	gm/100 ml	14.0-18.0	1
Mean Corpuscular Volume	μ^3	80.0-94.0	23
Mean Corpuscular Hb	micromicrogram	27.0-32.0	23
Mean Corpuscular Hb Conc	%	32.0-38.0	23
Platelet Count	thousands/mm^3	250.0-350.0	23
Prothrombin Time	seconds	12.0-17.0	20
Red Blood Cells	millions/mm^3	4.6-6.2	1
Sedimentation Rate	mm/hr	0-9.0	1
White Blood Cells	thousands/mm^3	4.5-11.0	1

*See footnote at end of Table II. 23E for bibliographic citations.

STAT
STAT

TABLE II. 23B

NORMAL RANGES: SERUM

Substance Measured	Units	Range	Reference*
Amylase	units/100 ml	80-150	1
Calcium	mg/100 ml	9.0-11.5	6
Chloride	mEq/l	95-110	6
Cholesterol, Free	mg/100 ml	32-100	6
Cholesterol Esters	mg/100 ml	105-155	6
Cholesterol, Total	mg/100 ml	130-330	6
Cholinesterase	pH/hr	0.58-1.37	24,25
Creatinine	mg/100 ml	1.0-2.0	6
Lipase	ml 0.05 Na-OH/100 ml	0-150	1
Phosphate, Inorganic	mg/100 ml	3.0-4.0	6
Potassium	mEq/l	4.6-5.8	6
Sodium	mEq/l	132-144	1
Total Protein	gm/100 ml	6.5-7.5	6
Urea Nitrogen	mg/100 ml	10-28	6

TABLE II. 23C

NORMAL RANGES: URINE

Substance Measured	Units	Range	Reference*
Acetone	mg/24 hr	0-15	18
Addis Count			
Casts Cells	per 2 hr	0-10,800	14
Epith & Pus Cells	per 2 hr	0-54,000	14
Red Blood Cells	per 2 hr	0-167	14
Ammonia N	mg/24 hr	40-70	12
Calcium	gm/24 hr	0.2-0.5	6
Chloride	gm/24 hr	10-15	6
Creatine	mg/24 hr	Less than 100	6
Creatinine	gm/24 hr	1.0-1.5	6
17-Ketosteroids	mg/24 hr	8-20	6
Nitrogen, Total	gm/24 hr	10-18	6
pH		4.8-8.0	10
Phosphorus	gm/24 hr	0.8-2.0	6
Potassium	mEq/24 hr	20-64	6
Sodium	mEq/24 hr	150-197	6
Specific Gravity		1.008-1.025	6
Titrable Acidity	mEq/24 hr	20-50	10
Urobilinogen	E.U./2 hr	0.3-1.5	9

TABLE II. 23D

NORMAL RANGES: FECES

Substance Measured	Units	Range	Reference*
Calcium	mg/24 hr	450-890	1
Fat	gm/24 hr	1-7	6
Nitrogen	gm/24 hr	0.7-2.1	6
Phosphate	gmP/24 hr	0.9-1.7	6
Potassium	mg/24 hr	62-290	3
Sodium	mg/24 hr	180-270	3

TABLE II. 23E

NORMAL RANGES: FUNCTIONAL TESTS

Substance Measured	Units	Range	Reference*
Cardiovascular Function			
Pulse, Resting	beats/min	72-85	19
Blood Pressure			
Systolic	mm Hg	90-150	19
Diastolic	mm Hg	65-85	19
Circulation Time	seconds	10-15	13
PR-Interval	sec	0.12-0.21	11
Psychomotor Function			
Reflex Time	sec	of order of 0.10	8
Reaction Time			
Sight	sec	0.19-0.22	8
Hearing	sec	0.12-0.18	8
Touch	sec	0.12-0.20	8
Renal Function			
Glomerular Filtration Rate	ml/min/1.73m²	131 ± 22	21
U/S Osmolar Ratio		1.0-4.1	22
Liver Function			
Cephalin Flocculation		0- ± 1	15
Respiratory Function			
Pulmonary Ventilation, Resting	l/m²/min	3.5 ± 10%	16
Oxygen Consumption, Resting, Digesting	ml/m²/min	155 ±10%	16
Respiratory Quotient, Basal		of order of 0.82	4
Insensible Water Loss	gm/hr	of order of 25 gm	17

STAT

TABLE II. 23E (Cont.)

Substance Measured	Units	Range	Reference*
	Body Composition		
Total Body Water.	% Body Wt	54.5-70.3	7
	l/70 kg **	38.2-49.2	
Extracellular Volume	% Body Wt	15.3-18.8	7
	l/70 kg **	10.7-13.2	
Body Fat	% Body Wt	4.9-16.8	5
	kg/70 kg **	3.4-11.8	

*Key to Bibliography. (1) Albritton, 1951; (2) Best and Sampter, 1951; (3) Bodansky and Bodansky, 1952; (4) Brody, 1945; (5) Brozek and Keys, 1951; (6) Consolazio, Johnson, and Marek, 1951; (7) Edelman et al., 1952; (8) Evans, 1949; (9) Han, 1952; (10) Hawk, Oser and Summerson, 1951; (11) Katz, 1946; (12) Kleiner, 1948; (13) Lange and Boyd, 1942; (14) Lippman, 1952; (15) Maclagen, 1951; (16) Newburgh, 1949; (17) Newburgh, Johnston, and Newburgh, 1948; (18) Present Report; (19) Pullen, 1944; (20) Shapiro and Weiner, 1949; (21) Sirota et al., 1950; (22) Smith, 1951; (23) Todd and Sanford, 1948; (24) Vorhaus and Kark, 1953; (25) Wolfsie and Winter, 1952.

**Calculated from data on % Body Wt.

SECTION III

RESULTS: TABLE OF CONTENTS

A. INTRODUCTION

This report comprises an analysis of the results of metabolic investigations made upon eight volunteer young men. Since it was essential to the planning and conduct of field trials that the control data be available as early as possible, detailed statistical analyses, cross correlations, and calculations of so-called "derived data" have been kept at a minimum. Such statistical analyses will be practically meaningful only when the data collected in field trials can be included, for then full cognizance can be taken of the manifold stresses of survival.

There are several ways in which such a mass of data as has been collected in this investigation can be recorded and presented. After due consideration of the possibilities, the following plan was adopted. In the main, the results will be presented according to the organs and systems of the body which were studied. In each section of the text dealing with a particular system or organ, the material will be subdivided according to experimental nutrient mixture. The original data will be summarized in these sections in figures and tables giving means and various measures of the variance of the means. The actual original data will be detailed in the several appendices. In the discussion (Section IV) an attempt will be made to synthesize these results and to arrive at preliminary conclusions regarding the optimum nutrient mixture for survival. At the same time the reader should remember that the present conclusions may be considered valid only for conditions of temperate environment, moderate activity, and no stress of a survival situation. Our conclusions may not be valid when the airman is subjected to the stresses of environmental extremes, the necessity for muscular work, or a survival situation. This reservation will not be repeated in the body of this section, but nonetheless it is very important.

B. BALANCES AND INTAKES

1. Caloric Balance

Results for caloric balance are summarized in Table III. 1, showing average daily caloric intake, and Table III. 2 and Figures III. 1 and 2 showing average daily caloric balance.

For the various experimental nutrient mixtures caloric intakes of 0, 1000, 2000 or 3000 were desired. The tables show that these specifications were in general well approximated. In the case of the meat bar at 1000 Cal on limited water, it proved necessary for the subjects to take to increase the caloric intake to 2000 in the second week; in the case of chocolate bar, the subjects just could not eat 2000 Cal per day as they were supposed to do. These two were the only major deviations from protocol.

*See Appendix III, Subject 7

TABLE III. 1

AVERAGE DAILY TOTAL CALORIC INTAKE

Experimental Nutrient Mixture	Water	Pre-Period Cal/day	Experimental I Cal/day	Experimental II Cal/day	Recovery Cal/day
M 3000	U	3657	3011	2996	4116
	L	3404	3008	2998	3405
ST 0	U	2995	0	0	4008
	L	3049	0	0	4488
0/100/0	U	3776	1000	995	4050
1000	L	3836	994	1006	4276
0/100/0	U	3484	1999	1992	5586
2000	L	3578	1990	1868	4470
30/0/70	U	3777	988	999	5811
1000	L	4221	997	2000	5046
30/0/70	U	4156	1993	1992	4869
2000	L	4334	1993	1993	4319
2/20/78	U	2789	999	1005	4911
1000	L	3789	999	4006	5374
2/20/78	U	3344	1950	1445	3833
2000	L	3247	1748	1000	2899
15/62/33	U	4239	1000	984	4587
1000	L	3470	998	999	4637
15/62/33	U	3402	1998	1974	3717
2000	L	3039	1885	1969	2802

Inspection of the tables and charts brings out several pertinent facts. First, caloric balance was quite well maintained at around 3000 Cal in all pre-periods. Second, caloric expenditure decreased in all experimental periods when the caloric intake was 1000 or 0; this decrease was measurable both in the resting metabolism and in the voluntary activity. Third, in all recovery periods after starvation or 1000-Calorie diets, there was a pronounced increase in caloric consumption, sometimes exceedingly high levels of 5000 or over. During these recovery periods the caloric balance was strongly positive. Fourth, these "rebounds" were far less pronounced after periods of 2000 Cal/day than they were after periods of 1000 or 0. Fifth, water intake had little if anything to do with the degree of caloric deficit, or in the "rebound" that followed low calorie regimens. Finally, there was no apparent correlation between caloric effects and the ratio of protein: carbohydrate: fat in the nutrient mixture.

These data are consistent with previous observations of others on resting, metabolism, and the clinical impressions of those who have studied low-calorie rations in the field. There is a kind of body economy during low-calorie diets. The resting metabolic rate decreases thus conserving calories; there is a diminution in

TABLE III. 2

AVERAGE DAILY CALORIC BALANCE IN RELATION TO EXPERIMENTAL NUTRIENT MIXTURE.

Experimental Nutrient Mixture	Water	Pre-Period Cal/day	Experimental I Cal/day	Experimental II Cal/day	Recovery Cal/day
N 3000	U	98	300	330	1080
	L	70	250	320	300
ST 9	U	-100	-2480	-2160	1520
	L	-200	-2340	-2400	1970
0/100/0	U	470	-1110	-1160	1530
1000	L	1000	-1270	-980	1510.
0/100/0	U	490	-480	-480	1240
2000	L	380	-810	-740	1270
30/0/70	U	1200	-1240	-1170	2870
1000	L	1030	-1510	-600	2630
30/0/70	U	1290	-1310	-900	1270
2000	L	1510	-670	-500	1500
2/20/78	U	160	-1060	-1010	2430
1000	L	910	-1080	-970	2520
2/20/78	U	-290	-1540	-2540	-910
2000	L	260	-530	-1220	520
15/52/33	U	1340	-1240	-1070	2330
1000	L	1100	-1510	-1360	1610
15/52/33	U	840	-740	-460	120
2000	L	520	-1160	-950	-680

voluntary activity, also conserving calories. In other words, there is less "calorie reserve" than normal, and less energy available for escape and evasion. Clearly, so far as calorie balance is concerned, there is no substitute for a ration that will keep the survivor in caloric balance.

CAPTION FOR FIGURES III. 1 and III. 2
WATER BALANCE I and II

Ordinates: Gain or Loss in Cal/day
Left Bar — Right Bar
Vertical Lines-Intake — Blank - Light Activity
Horizontal Lines - Moderate and Heavy Activity

Abscissae: Periods of Experiment
PRE - Week Prior to Experimental Periods
EXP - First and Second Weeks of Experimental Periods
REC - Week After Experimental Periods

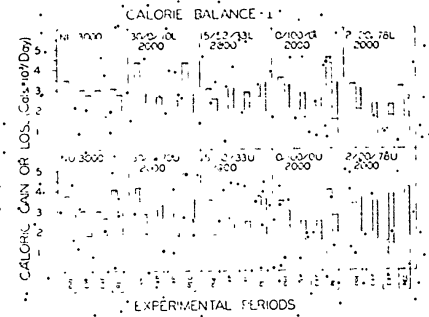

FIGURE III. 1

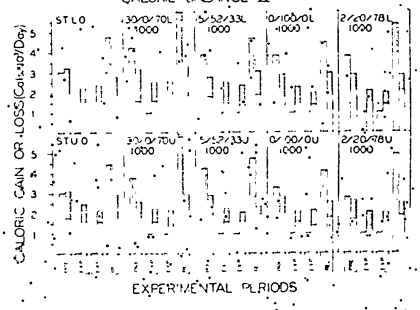

FIGURE III. 2

2. Water Balance

All of the pertinent data for water balance are to be found in Tables III. 3 and 4 and Figures III. 3 and 4. Suffice it to point out here that all of the several combinations of calorie level; water intake; nutrient ratios; and pre-, experimental, and recovery periods are presented with respect to fluid intake, metabolic water, insensible perspiration, and water balance.

Superficial inspection of the data brings out numerous striking facts, some of which are related to the merits of the several nutrient mixtures. The important points will emerge when one inspects the various categories: balance; voluntary water consumption and thirst; changes in insensible water loss; urinary volume; and minimal water requirements.

In general, water balance tended to be moderately positive in all pre-periods, strongly positive in all recovery periods, and negative in all experimental periods - even when water drinking ad lib. was permissible. One can conclude that a water deficit of varying degrees was almost always incurred in experimental periods and was made up or even overcompensated in the recovery periods. This "water deficit potential" can be estimated roughly by the

TABLE III. 3

AVERAGE DAILY TOTAL WATER CONSUMPTION:
LIQUIDS, PRE-FORMED, PLUS METABOLIC

Experimental Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
		ml/day	ml/day	ml/day	ml/day
N 3000	U	3293	3022	3097	3973
	L	3192	1330	1390	3146
ST 0	U	3224	1436	1633	3243
	L	2096	847	892	3597
0/100/0	U	2880	1452	1514	3515
1000	L	3631	1044	1051	3817
0/100/0	U	2779	1702	2260	3545
2000	L	3209	1194	1096	4208
30/0/70	U	3505	2377	2700	4229
1000	L	4370	1011	1167	6036
30/0/70	U	3049	1675	1989	3112
2000	L	4298	1123	1123	4127
2/20/78	U	2603	1274	1378	3549
1000	L	2904	1029	1037	3908
2/20/78	U	2776	1019	1403	2656
2000	L	2892	1067	963	3104
15/52/33	U	3835	1839	2095	3674
1000	L	2929	1025	1039	3019
15/52/33	U	3148	2905	2420	3019
2000	L	3013	1284	----	2991

TABLE III. 4

AVERAGE WATER BALANCE DURING SEVERAL EXPERIMENTAL REGIMENS

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
		l/day	l/day	l/day	l/day
N 3000	U	+0.62	+0.29	+0.19	+0.91
	L	+0.42	-0.45	-0.38	+0.87
ST 0	U	+0.07	-0.54	-0.51	+1.36
	L	+0.19	-0.62	-0.30	+1.32
0/100/0	U	+0.26	-0.15	-0.09	+1.33
1000	L	+0.62	-0.15	-0.28	+1.20
0/100/0	U	-0.12	+0.03	+0.56	+0.42
2000	L	+0.31	-0.12	+0.09	+1.32
2/20/78	U	-0.13	-0.70	+0.07	+0.66
1000	L	+2.13	-0.49	-0.08	+1.26
2/20/78	U	-0.34	+0.18	-0.03	+0.25
2000	L	+0.16	-0.45	-0.59	+1.60
15/52/33	U	+1.06	+0.01	+0.17	+1.51
1000	L	+0.29	-0.64	-0.35	+0.19
15/52/33	U	+0.19	+0.25	+0.98	+0.34
2000	L	+0.63	-0.11	----	+0.66
30/0/70	U	+0.90	+0.25	+0.01	+3.11
1000	L	+0.58	-0.57	-0.34	+0.92
30/0/70	U	-0.06	-0.46	-0.12	+0.58
2000	L	+0.65	-0.54	-0.32	+1.05

magnitude of the total fluid consumption plus metabolic water in the second experimental week, when water consumption was unlimited. If such calculations are made from the present data, those rations that imposed the least solute load were also those with the least "water deficit potential." The rations best in this category were the high carbohydrate diet and the high fat diet. Table III. 5 presents these data.

An important consideration in survival rations is the thirst-provoking capacity of the food. Especially when water is limited does this become an important consideration for the efficiency of the subject. Inspection of our data enables one to obtain a rough quantitative measure of this "thirst-provoking potential," because for each nutrient combination, some subjects were allowed unlimited water and others were limited to 900 ml/day. Therefore, the difference can be calculated between water consumption under these two conditions, and is a correlate of the thirst evoked by the nutrient combination. A tabulation of these rations will be found in Table III. 6. It is clear that the least thirst-provoking nutrient combinations are the pure carbohydrate diet at 1000 Cal and the high fat diet, i.e., those that impose the least solute load. The actual caloric intake seems to bear little, if any, relation to the

thirst provoking potential of the nutrient combination.

TABLE III. 5

WATER DEFICIT POTENTIAL OF VARIOUS NUTRIENT COMBINATIONS
(Defined as the sum of fluid intake plus metabolic water of ration, in second experimental week when water intake is unrestricted.)

Nutrient Mixture	Fluid Intake Plus Metabolic Water 1/day
N 3000	3.10
30/0/70 2000	1.99
30/0/70 1000	2.70
15/52/33 2000	3.05
15/52/33 1000	2.10
0/100/0 2000	2.26
0/100/0 1000	1.51
2/20/78 2000	1.40
2/20/78 1000	1.38

TABLE III. 6

THIRST-PROVOKING QUALITIES OF NUTRIENT COMBINATIONS
(Last Week of Experimental Periods)

Nutrient Combination	Fluid Intake 1/day	(Unlimited-Limited)
N U 3000	2.10	
N L 3000	0.50	1.60
ST U O	1.55	
ST L O	0.85	0.70
30/0/70 U 2000	1.75	
30/0/70 L 2000	0.90	0.85
30/0/70 U 1000	2.55	
30/0/70 L 1000	0.75	1.80
15/52/33 U 2000	2.35	
15/52/33 L 2000	0.90 (1st wk.)	1.45
15/52/33 U 1000	1.60	
15/52/33 L 1000	0.85	0.75
0/100/0 U 2000	1.70	
0/100/0 L 2000	0.65	1.05
0/100/0 U 1000	1.30	
0/100/0 L 1000	0.90	0.40
2/20/78 U 2000	1.15	
2/20/78 L 2000	0.90	0.25
2/20/78 U 1000	1.25	
2/20/78 L 1000	0.90	0.35

Quantitatively speaking, the insensible water loss; i.e., that from the skin and evaporated through the lungs, may become a significant percentage of the total water loss; and when urine volume is

small, insensible water loss may be much greater in volume than the urine. Therefore, in relation to the water requirements for various nutrient combinations, insensible water loss should be as low as possible. Inspection of Figures III. 3 and 4 and Tables III. 7 and 8

TABLE III. 7

MEAN PRE-PERIOD INSENSIBLE WATER LOSS (I.W.)

Subject No.	Insensible Perspiration Mean gm/hr	σ gm/hr	C.V. %	I.W. gm/m²/hr	I.W. kg/hr
1	[illegible]	6.6	15.0	24.2	0.63
2	55.7	13.4	24.1	30.3	0.79
3	63.3	13.5	21.4	31.3	0.79
4	75.3	----	----	36.2	0.91
5	52.6	17.2	32.7	29.2	0.81
6	32.7	4.5	13.8	18.7	0.51
7	43.0	4.0	9.3	22.8	0.64
8	36.9	3.1	8.4	19.3	0.53
12	49.1	5.1	10.4	24.7	0.66

TABLE III. 8

INSENSIBLE PERSPIRATION IN RELATION TO DIETARY REGIMEN
(Mean and Range, gm/hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	39.6	41.2	42.0	44.0
	29.2-65.2	22.1-63.3	23.3-67.1	32.2-84.8
ST O	51.4	35.2	29.1	39.4
	36.1-80.8	23.0-43.9	18.5-37.9	21.4-74.0
0/100/0	46.6	26.9	37.4	34.2
1000	34.2-77.6	23.3-33.4	28.5-41.5	32.9-35.7
0/100/0	51.5	34.0	29.4	63.6
2000	45.9-57.4	30.9-36.2	25.2-34.8	40.7-91.0
2/20/78	40.2	42.5	31.0	35.8
1000	31.6-48.9	36.5-48.5	25.9-36.2	31.5-39.2
2/20/78	63.9	38.0	40.6	38.2
2000	49.4-78.4	37.7-38.2	37.3-43.9	26.9-49.5
15/52/33	39.2	36.5	31.6	45.0
1000	24.6-66.1	25.3-50.8	22.8-38.4	25.9-69.7
15/52/33	51.8	48.9	34.4	56.3
2000	34.4-90.5	36.9-67.6	21.6-45.6	52.5-59.5
30/0/70	40.1	23.4	31.6	35.3
1000	31.8-45.4	16.9-29.9	22.7-40.6	34.0-36.7
30/0/70	47.-	38.0	32.6	38.0
2000	31.4-70.8	31.5-44.5	22.3-35.9	36.1-45.9

show two significant facts. First, in either the first or the second week of experimental periods, there tended to be a decrease of the insensible water loss below the pre- or the recovery level. This, no doubt, was associated with the decrease in metabolism that occurred during the experimental periods, a decrease related to the calorie deficit that occurred. Second, there is no discernible correlation between changes in the insensible water loss and the particular nutrient combination of the subject during experimental periods. Therefore, so far as insensible water loss is concerned, the merits of the various rations may be discussed without reference to it, and in relation to calories alone.

Minimal water requirements are critical in relation to survival situations. In this respect, that ration combination is best on which the subject remains in positive water balance with the least water intake (which includes water preformed in the food and available from oxidation). By inspection of Figures III. 3 and 4 it will be seen that those rations which impose the least solute load are best in this respect; i.e., pure carbohydrate and the high fat diets at 1000 Cal.

3. Nitrogen Balance

Average daily protein intake is shown in Table III. 9 as protein and in Table III. 10 as nitrogen. The daily intake of protein, as planned, ranged from 0 gm/day to the very high figure of almost 200 gm/day in one recovery period. When expressed in terms of N, the intake ranged from 0 gm/day to over 30 gm/day as an extreme and during the experimental periods ranged from 0 gm/day to 24 gm/day, being about 17:0 in the positive control mixture.

Pre-Period data for urinary excretion are presented in Table III. 11 and for the experimental regimens in Table III. 12. During

CAPTION FOR FIGURES III. 3 and III. 4
WATER BALANCE I and II

Ordinates: Water Gain or Loss in Liters/day

Left Bar (Gain)	Right Bar (Loss)
Vertical Lines - Fluid Intake	Horizontal Lines - Urine Excretion
Blank - Water Preformed in Diet and Formed from Oxidation of Nutrients	Diagonal Lines - Insensible Water Loss
	Solid Black - Water Lost in Blood and Feces

Abscissae: Periods of Experiment
PRE - Week Prior to Experimental Periods
EXP - First and Second Weeks of Experimental Periods
REC - Week after Experimental Periods

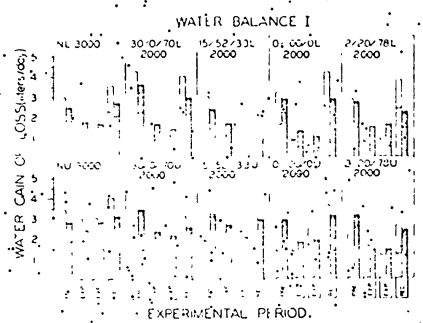

FIGURE III. 3

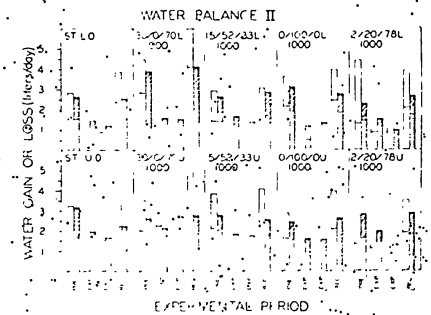

FIGURE III. 4

TABLE III. 9

AVERAGE DAILY PROTEIN INTAKE

Experimental Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
		gm/day	gm/day	gm/day	gm/day
N 3000	U	131	108	113	135
	L	126	107	108	104
ST 0	U	117	0	0	128
	L	120	0	0	148
0/100/0	U	118	0	0	143
1000	L	144	0	0	153
0/100/0	U	125	0	0	138
2000	L	120	0	0	142
30/0/70	U	140	74	75	178
1000	L	161	75	71	183
30/0/70	U	139	149	149	150
2000	L	149	149	149	145
2/20/78	U	115	0	5	149
1000	L	150	0	5	196
2/20/78	U	123	7	12	112
2000	L	130	12	4	108
15/52/33	U	160	37	37	163
1000	L	129	36	36	138
15/52/33	U	135	76	75	133
2000	L	112	72	69	88

pre-periods the urinary excretion was quite similar for all subjects. In experimental periods the urinary N varied with the nitrogen intake.

Pre-period data for fecal N are presented in Table III. 13 and for the experimental regimens in Table III. 14. Fecal N in the pre-period was of the order of 2.0 gm/day; during experimental diets it varied with the nitrogen intake but not in a constant fashion. Our data support the conclusion of Toscani and Whedon (1951) that it would be desirable in balance studies to dispense with fecal analysis, for it cannot be assumed either that a given subject excretes a constant amount of N (e.g., 1-3 gm/day) or that the fecal N is a constant percentage of the N intake (e.g., 10%).

Data for nitrogen balance are presented in Table III. 15 as net balances and in Figures III. 5 and 6 as comparisons with intake and output. Wide variations in nitrogen intake led to wide variations in nitrogen balance (Table III. 15). The range was from almost -11 gm N/day (starvation) to almost +14 gm N/day (one recovery period). Figures III. 5 and 6 give a detailed picture of all periods and all nutrient mixtures. It is clear that when the calorie intake was 3000 or over, nitrogen balance was well maintained.

TABLE III. 10

AVERAGE DAILY NITROGEN INTAKE

Experimental Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
		gm/day	gm/day	gm/day	gm/day
N 3000	U	20.9	17.5	18.0	21.6
	L	20.2	17.1	17.3	16.6
ST 0	U	14.8	0.0	0.0	20.5
	L	19.2	0.0	0.0	23.6
0/100/0	U	14.8	0.0	0.0	22.9
10	L	23.2	0.0	0.0	24.4
0/100/0	U	20.0	0.0	0.0	22.2
2000	L	19.2	0.0	0.0	22.8
30/0/70	U	22.4	11.9	12.0	28.5
1000	L	25.8	12.0	11.4	29.3
30/0/70	U	22.2	23.8	23.8	24.0
2000	L	23.7	23.8	23.8	23.2
2/20/78	U	18.4	0.0	0.9	23.9
1000	L	23.9	0.0	0.7	33.3
2/20/78	U	19.7	1.1	1.9	17.9
2000	L	20.8	1.9	0.6	17.4
15/52/33	U	25.6	5.8	5.9	26.0
1000	L	20.6	5.8	5.8	21.2
15/52/33	U	21.6	12.1	12.0	21.3
2000	L	17.8	11.5	11.1	14.0

TABLE III. 11

PRE-PERIOD DATA ON URINARY TOTAL NITROGEN
(Mean and Range)

Subject	Nitrogen, gm/24 hr Mean	Range
1	14.4	11.6-16.2
2	13.4	11.4-14.4
3	12.6	11.1-15.5
4	16.3	15.2-17.4
5	15.0	12.9-16.4
6	14.8	11.8-19.1
7	16.9	13.8-22.8
8	14.8	11.3-18.8
12	15.6	14.8-16.2

TABLE III. 12

URINARY EXCRETION OF NITROGEN
(Mean and Range, gm/24 hr)

Experimental Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	15.0	13.3	14.2	14.0
	10.3-22.8	10.1-16.0	12.0-16.6	8.4-19.3
ST 0	15.0	9.9	7.6	14.2
	10.6-18.1	6.7-13.2	4.7-9.5	9.3-16.5
0/100/0	14.8	6.7	5.1	13.9
1000	11.3-17.7	5.6-8.6	4.8-5.9	10.0-16.9
C/100/0	13.0	5.3	4.8	13.1
2000	11.1-14.8	4.3-6.1	3.5-7.4	12.3-14.0
2/20/78	13.0	8.4	6.3	11.8
1000	11.8-15.9	7.7-9.0	6.2-6.4	10.2-13.3
2/20/78	14.8	6.9	7.4	11.9
2000	13.9-15.8	6.5-7.2	5.6-9.1	10.7-13.1
15/52/33	14.8	10.2	9.4	14.6
1000	12.4-18.1	9.1-11.5	8.9-10.1	13.1-17.0
15/52/33	14.7	13.0	11.8	11.6
2000	12.2-17.4	11.2-14.4	10.4-13.4	10.1-13.9
30/0/70	16.4	16.9	15.9	18.1
1000	15.7-17.1	16.5-17.3	----	16.5-19.7
30/0/70	14.6	21.0	20.6	16.8
2000	13.9-15.2	20.6-21.4	17.6-23.7	16.5-17.1

TABLE III. 13

PRE-PERIOD DATA ON FECAL NITROGEN
(Mean and Range)

Subject	Nitrogen, gm/day Mean	Range
1	2.4	1.6-3.5
2	2.5	2.0-2.9
3	2.5	2.0-3.9
4	1.0	0.9-1.0
5	1.9	1.4-2.6
6	2.4	1.9-4.6
7	3.0	1.5-4.7
8	2.0	1.5-2.5
12	3.0	2.3-3.7

TABLE III. 14

FECAL NITROGEN
(Mean and Range, gm/day)

Experimental Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	2.6	2.4	2.2	3.4
	1.[illegible].2	1.6-2.9	1.2-3.2	1.0-4.0
ST 0	2.4	0.4	0.4	3.7
	1.[illegible].0	0.1-0.8	0.2-0.5	2.[illegible]-5.9
0/100/0	2.7	0.4	1.3	3.0
1000	2.[illegible].7	0.3-0.5	0.6-3.1	1.[illegible]-4.7
C/100/0	2.3	0.6	0.8	2.4
2000	2.[illegible]3.5	0.[illegible]-0.8	0.[illegible]-1.4	2.[illegible]-3.0
2/20/78	2.0	0.4	0.4	3.2
1000	[illegible]	0.3-0.4	0.3-0.4	2.6-3.9
2/20/78	2.3	0.5	0.9	2.4
2000	2.3-3.3	0.4-0.9	----	2.2-2.7
15/52/33	2.7	0.5	1.4	3.4
1000	1.[illegible].6	0.3-1.0	1.1-1.7	2.3-[illegible].3
15/52/33	[illegible].3	1.9	1.8	1.7
2000	2.[illegible]-2.9	1.1-2.3	1.3-2.4	1.0-2.1
30/0/70	2.7	0.7	0.9	4.0
1000	2.3-2.5	0.6-0.7	----	3.1-[illegible].9
30/0/70	2.2	1.4	1.4	2.4
2000	1.6-2.9	1.0-1.8	1.0-1.8	2.0-2.8

At 2000 Cal, nitrogen balance was positive only when the nitrogen intake was over 20 gm/day. At lesser progressively more negative when the nitrogen intake approached zero. At 1000 Cal, nitrogen balance was substantially negative regardless of the nutrient mixture. In starvation, nitrogen balance was strongly negative. The amount of water had little if any effect upon nitrogen balance. Finally, in all recovery periods the balance was strongly positive. This "rebound" is characteristic of almost all measurements made throughout this whole study during recovery periods.

In the studies of others a great deal of time and effort has been spent in elucidating the relations among nitrogen balance, nitrogen intake and caloric intake. For purposes of scrutiny, our data pertinent to these matters are presented in Figures III. 7 and 8. Data for experimental periods only are shown in Figure III. 7, as related to nutrient mixture, caloric intake, nitrogen intake, and water intake. It is clear that balance could be obtained at caloric intakes of 3000 with 17 gm N/day. At 2000 Cal/day, balance was attained with lesser intakes of nitrogen, viz., 24 gm N. At caloric intakes of 1000/day, increasing the nitrogen intake had only a small, if any, effect on improving the nitrogen balance within the range 0-12 gm N/day.

STAT
STAT

TABLE III. 15

AVERAGE NITROGEN BALANCE DURING EXPERIMENTAL REGIMENS

Experimental Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
		gm/day	gm/day	gm/day	gm/day
N 3000	U	+2.7	+2.0	-0.2	+3.0
	L	+3.2	+3.0	+1.0	-1.5
ST 0	U	+2.0	-10.6	-7.5	+4.7
	L	-0.4	-10.8	-10.1	+5.9
0/100/0	U	+3.0	-6.7	-6.4	+5.6
1000	L	+3.1	-8.3	-7.9	+6.7
0/100/0	U	+3.8	-5.6	-5.9	+5.5
2000	L	+2.7	-7.4	-5.3	+5.8
2/20/78	U	+0.0	-8.5	-6.6	10.7
1000	L	+9.6	-9.7	-6.9	13.7
2/30/78	U	+2.9	-6.7	-5.2	+4.1
2000	L	+1.1	-5.8	-9.5	+1.5
15/52/33	U	+5.7	-5.5	-5.1	+7.3
1000	L	+4.9	-5.0	-5.4	+5.5
7/52/33	U	+3.9	-4.2	-2.3	+5.1
2000	L	+1.4	-3.0	-0.4	+0.6
30/0/70	U	+3.7	-6.7	-5.7	+7.5
1000	L	+5.9	-5.4	-3.6	+7.5
30/0/70	U	+4.9	+0.2	-2.6	+4.4
2000	L	+6.3	+1.8	+4.6	+3.5

CAPTION FOR FIGURES III. 5 and III. 6
NITROGEN BALANCE I and II

Ordinates: Nitrogen Gain or Loss in Grams/day.
Left Bar (Gain) Right Bar (Loss)
Vertical Lines - Dietary Intake
Blank - Urinary N
Horizontal Lines - Fecal N
Solid Black - Cutaneous and Blood Loss of N

Abscissae: Periods of Experiment
PRE - Week Prior to Experimental Periods
EXP - First and Second Experimental Periods
REC - Week after Experimental Periods

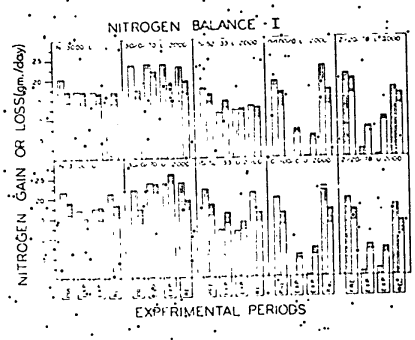

FIGURE III. 5

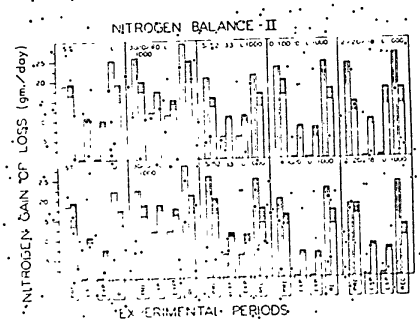

FIGURE III. 6

STAT
STAT

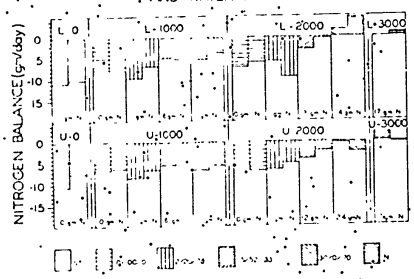

FIGURE III. 7. NITROGEN BALANCE VS. NITROGEN, CALORIC, AND WATER INTAKE

In Figure III. 8, these data are presented in a different fashion. All values for each caloric level were averaged, and nitrogen intake was plotted against nitrogen balance. Included also are the averages for all pre-periods and for all recovery periods. Three striking features are observable. First, in general the higher the nitrogen intake, the more positive was the nitrogen balance. Second, addition of calories, with nitrogen intake constant, improved the nitrogen balance. Third, caloric intake being constant, isocaloric replacement of fat or carbohydrate with protein improved the nitrogen balance at 2000 Cal, an improvement of 1 gm in balance could be achieved with 3.3 gm N, whereas at 1000 Cal an improvement of 1 gm in balance could be achieved with .5 or more gm N.

Thus, our data agree with the older literature, that improvement in nitrogen balance can be achieved most importantly by increasing caloric intake, and next most importantly by increasing nitrogen intake (Peters and Van Slyke, 1946). It has been claimed (Schwimmer and McGavack, 1948) that isocaloric addition of nitrogen at 900 Cal/day will decrease the negative nitrogen balance of human subjects. These original data were open to question because (1) the balances were virtual (no stools were analyzed) and (2)

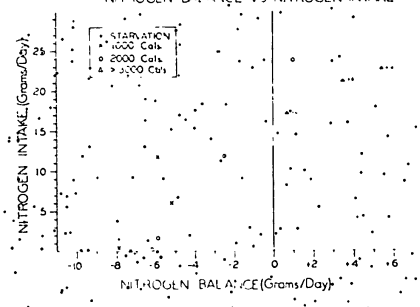

FIGURE III. 8. NITROGEN BALANCE VS. NITROGEN INTAKE.

the decreases were possibly within the experimental error (no statistical analyses were performed). These claims could not be confirmed by the original investigators (Schwimmer et al. 1952) nor by Quinn et al. (1953a and b). Our data indicate a substantial sparing action of increasing nitrogen from 2 to 15%. Additional nitrogen, up to 30%, had no apparent further sparing action.

In summary, we find that the two important factors in maintaining nitrogen balance are adequate caloric intake and adequate nitrogen intake. It is entirely possible that there is a minimum caloric intake, below which it is difficult if not impossible to achieve nitrogen balance, regardless of the actual nitrogen intake. If the above hypothesis is true, this minimum obligatory caloric intake might be substantially increased in the cold, or when the subject is expected to expend extra calories in exercise, as in escape and evasion. This factor should certainly be taken into account as part of the "survival potential" of a ration, even though we do not know for how long negative nitrogen balances of varying degrees may be incurred without serious inefficiency.

STAT

It might be argued that the conclusions from our data might be biased, statistically speaking, by a possible carry-over effect from prior periods of negative nitrogen balance followed by periods of repletion. We consider that such a criticism cannot be supported by the facts. In the first place, the mean body weight in pre-periods remained remarkably constant in all subjects, which fact suggests a recurring return to the initial physiological state after periods of depletion. In the second place, it is possible to group the data for two subjects (5 and 6) in a chronological table (Table III. 16) for the five consecutive phases. There is no evidence

TABLE III. 16

NITROGEN BALANCE IN TWO SUBJECTS SUCCESSIVELY ON LOW CALORIC INTAKES

Subject No.	Intake in Experimental Periods		Nitrogen Balance, gm/day			Recovery
	Calories	Nitrogen gm	Pre-Period	Experimental I	Experimental II	
5	0	0	+1.2	-8.0	--	+3.7
6	0	0	+0.4	-13.7	--	+5.8
5	1000	0	+1.3	-7.2	-6.0	+5.6
6	1000	0	+3.4	-6.2	-6.5	+3.7
5	1000	1	+0.0	-8.5	-6.6	10.7
6	1000	1	+9.6	-9.7	-6.7	13.7
5	1000	6	+4.1	-3.2	-4.4	+6.4
6	1000	6	+2.3	-6.2	-4.1	+5.1
5	3000	17	+3.8	+2.7	+1.8	+0.6
6	3000	17	+2.1	-1.4	+1.3	-2.4

that repeated exposure to low nitrogen intakes had any significant effect on the nitrogen balance in subsequent periods of low nitrogen intake. Finally, a statistical analysis was made of the effects on nitrogen balance in pairs of subjects when they were on 0/100/0 1000, 0/100/0 2000, 15/52/33 1000, or 15/52/33 2000, the preceding experimental mixture having been different for each pair (Table III. 17A). In order to interpret Table III. 17A the inter-individual variability in nitrogen balance was calculated for all eight subjects when they were in markedly negative nitrogen balance (ST 0) and when they were on the positive control regimen. The mean standard deviation was 1.8 and was independent of the level of the nitrogen balance. Referring back to Table. III. 17A it will be seen that the differences in nitrogen balance which could have been related to differences in nitrogen intake of the preceding regimen were never greater than twice the standard deviations given in Table III. 17B. Therefore, preceding dietary experience did not have any significant effect on nitrogen balance during the restricted regimens studied.

TABLE III. 17

A. INFLUENCE OF PRECEDING DIET ON NITROGEN BALANCE IN PAIRS OF SUBJECTS

Preceding Experimental Mixture	Experimental Mixture	Nitrogen Balance Mean	Range
ST 0	0/100/0 1000	-6.5	-6.2 to -7.2
N 3000		-8.2	-6.2 to -9.9
15/52/33 1000	0/100/0 2000	-6.1	-5.0 to -9.2
2/20/78 2000		-6.8	-4.6 to -7.3
2/20/78 1000	15/52/33 1000	-5.0	-4.1 to -6.2
30/0/70 2000		-6.5	-4.7 to -8.3
0/100/0 1000	15/52/33 2000	-1.5	-0.1 to -3.7
Pre-period		-4.0	-3.1 to -4.6

B. STANDARD DEVIATION VS. MEAN NITROGEN BALANCE IN EIGHT SUBJECTS

Experimental Nutrient Mixture	Experimental Week	Nitrogen Balance Mean	σ
ST 0	I	-10.7	2.0
	II	-8.8	1.7
N 3000	I	+1.0	1.9
	II	+0.4	1.5

4. Inorganic Substances

Although each of the inorganic metabolites will be treated individually in subsequent sections 4, 5, 6, 7 and 8, two aspects will be discussed in general terms at this point. Pre-period data for urinary and fecal excretion of sodium, potassium, chloride, phosphate, and calcium are shown in Table III. 18. Data for the fecal excretion of these same substances (except for chloride) are shown in Table III. 19. These may be taken as the characteristics of the subjects during pre-periods.

The second general matter concerns the calculation of the intake of the several inorganic metabolites. In general, the intake was calculated from analytical data for the individual food items. There was no reason to question the reliability of the food analyses in the case of calcium, phosphorus and chloride. However, it proved necessary to calculate correction factors for sodium and potassium.

A systematic discrepancy was found upon calculation of the dietary intakes of sodium and potassium. It now appears that there may have been too high a temperature in the muffles that were used to ash the specimens prior to flame photometry.

STAT

TABLE III. 18

PRE-PERIOD DATA ON URINARY EXCRETION OF SODIUM, POTASSIUM, CHLORIDE, PHOSPHATE, AND CALCIUM

Subject No.	Sodium mEq/24hr		Potassium mEq/24hr		Chloride gm NaCl/24hr		Phosphate gm P/24hr		Calcium mg/24hr	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
1	370	294-450	74.1	55.9-93.0	20.1	13.5-26.2	1.02	0.83-1.17	312	222-436
2	335	315-351	66.0	58.1-85.4	17.7	15.6-19.7	1.13	0.90-1.39	290	218-420
3	291	222-358	64.4	38.0-88.0	15.3	11.8-18.6	1.13	0.77-1.44	249	135-468
4	373	358-389	68.0	63.9-72.0	18.1	16.6-19.7	1.44	1.34-1.55	349	---
5	344	311-405	71.0	54.4-84.0	19.3	16.3-21.9	1.03	0.78-1.25	178	121-218
6	362	303-414	79.1	63.4-100.0	19.8	15.9-23.8	1.20	0.89-1.53	309	228-422
7	406	374-430	85.6	72.6-110.0	21.8	19.0-24.4	1.10	0.62-1.42	264	220-304
8	351	373-389	73.8	52.1-106.0	19.7	17.0-24.3	1.10	0.80-1.23	243	149-298
12	392	359-468	70.7	60.4-88.0	20.9	18.2-27.4	1.18	0.97-1.39	165	102-224

TABLE III. 19

PRE-PERIOD DATA ON MEAN DAILY FECAL SODIUM, POTASSIUM, PHOSPHORUS, AND CALCIUM (Mean And Range)

Subject No.	Sodium mg		Potassium mg	
	Mean	Range	Mean	Range
1	31	0-82	380	267-586
2	55	10-86	507	200-686
3	118	54-171	508	200-875
4	---	---	---	---
5	37	5-59	273	180-343
6	50	29-71	410	171-873
7	124	29-430	766	429-1159
8	44	21-64	351	229-457
12	107	67-129	456	204-543

Subject No.	Phosphorus gm		Calcium mg	
	Mean	Range	Mean	Range
1	0.38	0.23-0.74	598	322-985
2	0.48	0.18-0.66	584	179-920
3	0.37	0.17-0.65	569	250-805
4	0.26	0.21-0.30	234	---
5	0.40	0.37-0.58	372	347-392
6	0.50	0.37-0.92	602	392-967
7	0.58	0.29-1.64	638	189-1447
8	0.40	0.24-0.71	412	186-682
12	0.52	0.41-0.65	783	665-1032

STAT

If there were too high a temperature, potassium and sodium would be volatilized, resulting in low values. Potassium, having a higher vapor tension than sodium, would have been volatilized to the greater extent. Now, bigger and better muffles have been procured, and when they have been installed, all foods will be analyzed once more. Until that time, an empirical correction factor will be used to allow a tentative calculation of sodium and potassium balances.

The empirical correction factor has been calculated from the chloride balance. Two general assumptions have been made. First, chloride in the food was accurately estimated. Second, the urinary excretion of sodium and potassium resembled closely that of chloride. The first assumption is based on the apparent reliability of the chloride balances. The second assumption is based on the general literature concerning the mutual relations among chloride, sodium, and potassium excretion. The actual equation used for computing the calculated food intake of sodium and potassium is:

Calculated intake = (Intake as analyzed) x (f)

Where f = $\frac{\text{(mean chloride intake in pre-period)}}{\text{(mean urinary chloride excretion in pre-period)}}$ x

$\frac{\text{(mean urinary excretion of Na or K, pre-period)}}{\text{(mean intake as analyzed, pre-period)}}$

For sodium, this factor is:

$$1.18 \times 1.15 = 1.36$$

For potassium, this factor is:

$$1.18 \times 1.57 = 1.85$$

Both sodium and potassium balances have been computed with these corrected food intakes.

5. Sodium Balance

The data for sodium intake are summarized in Table III. 20, for urinary excretion in Table III. 21; for fecal sodium in Table III. 22, and for the virtual balances in Table III. 23. All of the above data are presented graphically together in Figure III. 9 and Figure III. 10, which show the virtual sodium balance.

Several salient points can be seen upon inspection of the tables and charts. First, the fecal sodium was negligible in comparison with the urinary excretion. This agrees with the older literature (Consolazio, Johnson and Marek, 1951). Second, the intake when

TABLE III. 20

AVERAGE DAILY CORRECTED SODIUM INTAKE
(gm Na/day)

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	U	11.8	7.7	7.2	10.0
	L	9.6	6.5	6.5	6.4
ST 0	U	3.3	0.1	0.0	10.1
	L	9.3	0.0	0.0	11.5
0/100/0	U	8.7	0.1	0.1	9.9
1000	L	10.2	0.0	0.0	10.3
0/100/0	U	8.7	0.1	0.1	8.5
2000	L	8.7	0.0	0.1	8.1
30/0/70	U	10.8	0.7	0.7	11.5
1000	L	11.2	0.6	3.2*	12.3
30/0/70	U	9.2	1.3	1.3	11.5
2000	L	11.1	1.3	1.3	9.4
2/20/78	U	10.5	0.0	1.8	11.5
1000	L	12.5	0.0	1.5	11.9
2/20/78	U	7.9	3.1	3.4	6.7
2000	L	13.1	4.0	4.0	6.7
15/52/33	U	11.5	0.8	0.8	9.5
1000	L	9.3	0.8	0.8	7.9
15/52/33	U	10.3	2.4	2.5	10.7
2000	L	8.7	2.3	2.6	5.4

*Added 1000 Cal/day of carbohydrate.

5-in-1 was used (pre-periods and recovery) was very high, almost pathologically so, up to 15 gm Na/day. This is a definite black mark against the 5-in-1 ration if there is any prospect of limited water. Third, the virtual balance tended to be slightly positive in all pre- and recovery periods. Fourth, balance was sometimes achieved in the second week of restricted periods, even when the intake was very low. Finally, there was no apparent relation between balance and either nutrient mixture or water intake.

Two points need emphasizing. First, so far as the survival rations were concerned, several of them were exceedingly low in sodium. Under temperate conditions when sweating was minimal, our subjects were usually able to achieve approximate balance in the second week of survival, even when the intake was less than 1 gm Na/day. However, if sweating were profuse, with consequent loss of sodium, strong negative balance with respect to sodium might occur. Thus, the "survival potential" of these rations in hot climates might be improved by a small addition of sodium chloride. Second, the sodium content of the 5-in-1 ration is excessively high. When water is available without limit, this

STAT

TABLE III. 21

URINARY EXCRETION OF SODIUM
(Mean and Range, mEq/24hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	340	272	279	318
	222-430	151-358	139-360	216-456
ST 0	373	63	11	405
	294-414	37-92	0-23	232-521
0/100/0	331	41	32	311
1000	273-407	36-49	20-43	269-352
0/100/0	351	52	0	317
2000	256-450	44-58	----	272-413
2/20/78	342	28	46	422
1000	311-372	27-28	47-48	402-441
2/20/78	375	102	123	293
2000	282-468	43-162	92-154	268-318
15/52/33	354	59	39	328
1000	320-394	48-64	36-48	256-396
15/52/33	356	118	109	253
2000	334-374	71-143	80-140	195-309
30/0/70	396	82	85	336
1000	374-417	80-83	----	319-353
30/0/70	298	96	64	287
2000	315-382	95-96	44-84	284-290

high solute load can be handled, presumably. However, if there is any danger of restriction of water, then this excessive solute load might be a definite disadvantage.

6. Potassium Balance

Data for potassium intake are given in Table III. 24, for urinary excretion of potassium in Table III. 25, for fecal potassium in Table III. 26, and for potassium balance in Table III. 27. These various data are summarized graphically in Figures III. 11 and III. 12, which show the relevant factors concerned with potassium balance.

During the various experimental regimens, potassium intake was extremely various. It ranged from 0 gm K/day in the pure carbohydrate diets to over 5 in many recovery periods. In the positive control periods the intake was not high enough to achieve balance, owing to the dietetic necessity to keep to a minimum certain high potassium foods; e.g., watery vegetables.

TABLE III. 22

FECAL SODIUM.
(mg/day)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	66	58	76	63
	10-165	29-126	36-169	14-150
ST 0	67	26	20	92
	10-100	0-43	7-36	14-171
0/100/0	127	34	25	246
1000	5-430	5-86	5-45	154-660
0/100/0	88	30	30	186
2000	66-102	14-45	14-45	110-286
2/20/78	48	9	9	54
1000	43-50	0-18	0-18	21-86
2/20/78	150	36	68	135
2000	129-171	5-68	----	56-214
15/52/33	49	14	38	93
1000	31-71	0-32	24-53	21-206
15/52/33	35	59	58	46
2000	21-54	14-94	38-100	17-92
30/0/70	62	12	14	54
1000	50-75	7-16	7-21	45-64
30/0/70	48	8	8	83
2000	10-86	7-10	7-10	35-131

The urinary excretion of potassium varied widely, but never reached zero, even on the zero intake regimens as it did in the case of sodium. Presumably tissue potassium was released as a result of caloric deficiency, and thus the urinary potassium never reached zero.

Fecal potassium accounts for from 10 to 20% of the total potassium excretion. It did vary with intake, but never reached zero, even in starvation (Table III. 26).

Unlike sodium balance, potassium balance tended to be negative in pre-periods and in all experimental periods (Table III. 27 and Figures III. 11 and III. 12). In absolute magnitude, negative balance tended to be greatest when the intake was least. There was no discernible striking effect either of caloric level, water intake, or distribution of calories among nitrogen, carbohydrate and fat. As with nitrogen and phosphorus, there tended to be a sharp "rebound" in recovery periods. Presumably potassium depletion in the experimental periods was of such magnitude that strong positive balances were encountered in recovery periods. This phenomenon was not observed in sodium and chloride balances. The question is

STAT
STAT

TABLE III. 23

AVERAGE DAILY CORRECTED SODIUM BALANCE DURING SEVERAL EXPERIMENTAL REGIMENS

Nutrient Mixture	Water	Pre-Period gm/day	Experimental I gm/day	Experimental II gm/day	Recovery gm/day
N 3000	U	+3.1	+0.9	+0.1	+1.7
	L	+2.3	+0.7	+0.6	+0.1
Sf 0	U	-0.1	-1.2	-0.1	+1.1
	L	+0.2	-1.6	-0.4	+1.8
0/100/0	U	+1.7	-1.1	-0.7	+2.6
1000	L	+1.7	-0.9	-0.7	+2.9
0/100/0	U	+0.6	-1.0	+0.1	+0.3
2000	L	+0.5	-1.3	+0.1	+1.5
2/20/78	U	+3.3	-0.6	+0.7	+1.4
1000	L	+2.8	-0.6	+0.4	+1.2
2/20/78	U	+1.2	+2.0	+1.2	+0.3
2000	L	+2.2	+0.3	+0.5	-0.7
15/52/33	U	+2.5	-0.5	-0.3	+1.1
1000	L	+1.7	-0.7	0.0	+1.0
15/52/33	U	+1.9	-0.6	0.0	+3.6
2000	L	+0.7	-0.2	0.0	+0.1
30/0/70	U	+1.3	-1.2	-0.8	+4.2
1000	L	+1.5	-1.2	+1.3*	+4.1
30/0/70	U	+2.0	-0.9	-1.0	+4.9
2000	L	+2.3	-0.9	-0.3	+2.9

*Added 1000 Cal/day of carbohydrate

CAPTION FOR FIGURES III. 9 and III. 10
SODIUM BALANCE I and II
(Intakes Calculated)

Ordinates: Sodium Gain and Loss in Grams/Day
Left Bar (gain) Right Bar (Loss)
Vertical Lines - Dietary Intake
Blank - Urinary Excretion
Solid Black - Fecal Loss

Abscissae: Periods of Experiment
PRE - Week Prior to Experimental Periods
EXP - First and Second Weeks of Experimental Periods
REC - Week after Experimental Periods

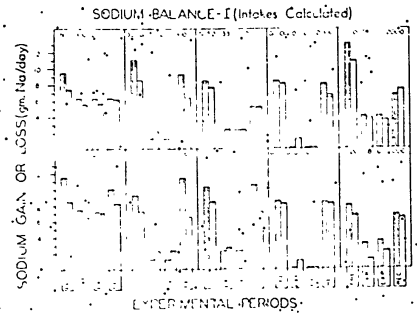

FIGURE III. 9

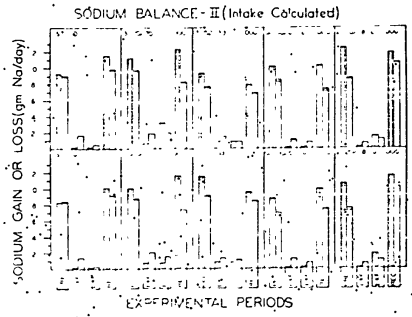

FIGURE III. 10

STAT

TABLE III. 24

AVERAGE DAILY CORRECTED POTASSIUM INTAKE
(gm K/day)

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	U	3.93	1.88	1.92	5.16
	L	3.57	1.51	1.70	4.64
ST 0	U	2.66	0.0	0.0	4.18
	L	3.22	0.0	0.0	4.93
0/100/0	U	3.19	0.01	0.01	5.07
1000	L	3.78	0.01	0.06	4.89
0/100/0	U	3.27	0.02	0.33	4.57
2000	L	3.71	0.02	0.09	5.45
30/0/70	U	3.95	0.27	0.27	5.02
1000	L	3.53	0.27	1.12*	6.18
30/0/70	U	4.72	0.53	0.53	6.42
2000	L	4.55	0.52	0.52	5.08
2/20/78	U	3.35	0.01	0.09	5.18
1000	L	4.54	0.01	0.08	8.19
2/20/78	U	3.13	0.10	0.17	6.18
2000	L	3.52	0.19	0.06	3.30
15/52/33	U	4.51	0.33	0.36	6.36
1000	L	3.69	0.30	0.31	4.52
15/52/33	U	4.08	1.20	1.09	4.22
2000	L	2.95	1.07	1.36	2.93

*Added 1000 Cal/day of carbohydrate.

certainly pertinent: What affect does acute potassium deficiency have upon the organic function and overall efficiency of the castaway?

7. Calcium Balance

The average daily intake of calcium is shown in Table III. 28; the urinary excretion in Table III. 29; the fecal calcium, in Table III. 30; and the balance, in Table III. 31. Graphically, these data are presented in Figure III. 13 and Figure III. 14.

Some of the calcium intake was accounted for always by the calcium in the drinking water; ordinary tap water was presented, not distilled water, and our local water is very hard. Therefore, the lowest intake was 0.05 gm Ca/day. The highest, in recovery periods was up to 2 gm Ca/day. It was low in all experimental periods, even the positive control, for calcium rich foods had to be excluded for dietetic reasons: Water vegetables high in calcium would have contributed too much water for the N L 3000 regimen.

TABLE III. 25

URINARY EXCRETION OF POTASSIUM
(Mean and Range, mEq/24hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	75	54	42	74
	60-106	40-89	30-62	60-121
ST 0	69	45	21	86
	51-88	32-57	13-30	58-128
0/100/0	74	31	26	82
1000	65-93	24-40	20-33	61-128
0/100/0	71	24	19	69
2000	60-93	20-28	14-24	54-91
2/20/78	80	28	24	94
1000	73-96	20-34	22-27	80-108
2/20/78	73	30	18	69
2000	67-88	27-33	15-22	66-72
15/52/33	76	38	32	93
1000	60-100	36-60	30-38	81-110
15/52/33	80	65	64	64
2000	64-110	50-99	46-96	38-87
30/0/70	78	61	49	78
1000	74-81	60-62	---	69-86
30/0/70	76	64	44	60
2000	70-81	63-65	33-55	59-63

The urinary excretion varied widely (Table III. 29), and in general paralleled the intake. One exceedingly interesting observation was made during the pure carbohydrate regimens: the urinary calcium became very low, and indeed was literally zero for one week for two subjects. No other regimens showed this, and it is a very intriguing phenomenon, if the urinary excretion of calcium can indeed be depressed by a pure carbohydrate diet. A cursory survey of the literature has revealed no reports on this subject.

Fecal calcium also varied widely, being highest in recovery periods and lowest in starvation. In general, it correlated with the intake (Table III. 30).

Calcium balance tended to be negative in all experimental periods, in most pre-periods, and in some recovery periods (Table III. 31 and Figures III. 13 and III. 14). In general, therefore, all these rations are low in utilizable calcium, even the 5-in-1. It is most unlikely that slight negative balance would be deleterious in a survival situation, but this factor might become important in chronic situations such as guerilla warfare or mass civilian undernutrition.

STAT

TABLE III. 26

FECAL POTASSIUM
(mg/day)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	481	388	419	418
	180-1159	196-566	236-697	200-857
ST 0	416	60	61	614
	267-666	0-169	18-69	272-1133
0/100/0	402	112	440	620
1000	171-771	94-135	107-774	410-857
0/100/0	500	186	259	837
2000	204-633	89-237	180-386	719-1129
2/20/78	296	144	144	528
1000	273-318	128-160	128-160	286-769
2/20/78	109	135	270	540
2000	543-875	0-270	---	257-822
15/52/33	469	44	316	444
1000	273-873	14-67	189-490	93-893
15/52/33	367	424	353	302
2000	200-646	229-571	250-500	117-514
30/0/70	696	132	256	794
1000	371-1021	94-171	---	628-966
30/0/70	436	250	254	266
2000	286-586	164-337	164-343	500-833

No general correlation could be detected between calcium balance and the factors total calories, water intake, or nutrient ratios. The one exception was the urinary excretion as related to carbohydrate intake, as discussed above.

8. Phosphorus Balance

The various aspects of phosphorus intake, urinary excretion, fecal excretion, and balance are shown in Tables III. 32, III. 33, III. 34, and III. 35. Figures III. 15 and III. 16 present these data graphically.

Intake of phosphorus ranged from 0 to 3.2 gm P/day. The mean for pre-periods was in the neighborhood of 1.6 gm P/day (Table III. 32). These variations in intake were accompanied by roughly corresponding fluctuations in urinary excretion (Table III. 33), and more strikingly in fecal excretion (Table III. 34). The urinary excretion never reached excessively low figures, but the fecal excretion did approach zero when the intake approached zero. This phenomenon raises interesting questions regarding the differential treatment of phosphate by the kidney and the gut, but our data do not allow an analysis of the mechanisms.

TABLE III. 27

AVERAGE DAILY CORRECTED POTASSIUM BALANCE DURING EXPERIMENTAL REGIMENS

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
		gm/day	gm/day	gm/day	gm/day
N 3000	U	+0.59	-0.37	-0.41	+1.37
	L	-1.15	-1.26	-0.21	+1.04
ST 0	U	-0.27	-1.91	-0.77	+0.25
	L	+0.32	-1.72	-0.81	+0.98
0/100/0	U	+0.23	-1.07	-0.98	+0.56
1000	L	+0.17	-1.53	-1.53	+1.71
0/100/0	U	+0.27	-1.09	-0.79	+1.11
2000	L	+0.13	-1.17	-0.78	+1.81
2/20/78	U	+0.22	-0.90	-0.90	+1.76
1000	L	+0.86	-1.48	-1.14	+3.21
2/20/78	U	-1.16	-1.23	-0.69	+2.94
2000	L	+0.36	-1.10	-0.80	+0.46
15/52/33	U	+0.59	-1.61	-1.27	+1.65
1000	L	+0.63	-1.66	-1.21	+1.03
15/52/33	U	+0.25	-2.35	-2.05	+0.31
2000	L	-0.18	-2.06	-0.90	+0.53
30/0/70	U	-0.22	-2.25	-1.82	+1.70
1000	L	+0.66	-2.15	-1.91*	+1.86
30/0/70	U	+1.39	-2.26	-1.96	+3.46
2000	L	+1.09	-2.18	-0.93	+1.97

*Added 1000 Cal/day of carbohydrate

Balances tended to be strongly negative in all experimental periods, even positive control, and slightly negative in pre-periods. In recovery, there was a "rebound," which indicates a substantial deficiency in the experimental periods (Table III. 35 and Figures III. 15 and III. 16). No close correlation was detectable between the phosphorus balance and the variables calorie intake, water intake, and nutrient ratios.

It is difficult to state any positive conclusions concerning possible deleterious effects of phosphorus deficiency for short periods of time, as the literature does not deal with the sort of acute situations we studied. It is perfectly possible, however, that the "survival potential" of the various survival mixtures we tested was adversely affected by phosphorus deficiency. This point warrants careful future study.

STAT
STAT

9. Chloride Balance

In general, chloride metabolism paralleled that of sodium. Data for chloride were computed for intake (Table III. 36), urinary excretion (Table III. 37) and virtual balance (Table III. 38). Fecal analyses were not performed, because the chloride and sodium contents of feces are so low as to be negligible in comparison with the urinary excretion, and hence can be neglected for practical purposes. Chloride balance is presented graphically in Figures III. 17 and III. 18.

As with sodium, intakes and urinary excretions were excessively high in pre-periods and recovery periods. However, in those experimental periods when the intake was nearly zero, the urinary excretion dropped, but the virtual balance was nearly positive in the second week. There was an economy of sodium and chloride. No substantial "rebound" phenomena were to be detected in recovery periods; this finding suggests the conclusion that chloride depletion was not severe in our subjects during the two weeks of restriction.

The same warnings hold for chloride as for sodium. First, the 5-in-1 has an excessively high chloride content, which might be definitely detrimental if water had to be restricted. Second, under conditions of heat stress, when chloride is lost in the sweat in substantial amounts, the "survival potential" of the survival mixtures might be impaired by lack of chloride. Heat exhaustion and other diseases of the heat are the inevitable sequelae of sodium and chloride deficiency if long continued in hot climates.

CAPTION FOR FIGURES III. 11 and 12
POTASSIUM BALANCE I and II
(Intakes Calculated)

Ordinates: Potassium Gain and Loss in Grams/Day
Left Bar (Gain) — Vertical Lines - Dietary Intake
Right Bar (Loss) — Blank - Urinary Excretion; Horizontal Lines - Fecal Loss

Abscissae: Periods of Experiment
PRE - Week Prior to Experimental Periods
EXP - First and Second Week of Experimental Periods
REC - Week after Experimental Periods

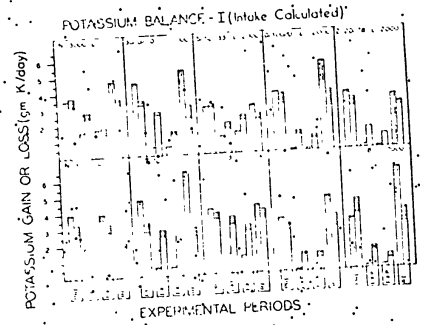

FIGURE III. 11

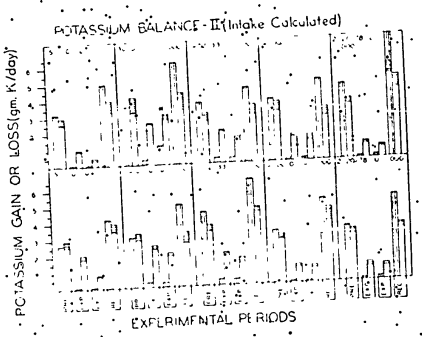

FIGURE III..12

STAT
STAT

TABLE III. 28

AVERAGE DAILY CALCIUM INTAKE

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
		gm/day	gm/day	gm/day	gm/day
N 3000	U	1.06	0.56	0.59	1.26
	L	0.75	0.44	0.47	1.15
ST 0	U	0.70	0.08	0.09	1.36
	L	0.61	0.04	0.05	1.44
0/100/0	U	0.70	0.07	0.07	1.36
1000	L	0.82	0.05	0.05	1.40
0/100/0	U	0.80	0.15	0.15	1.97
2000	L	0.82	0.06	0.06	1.67
30/0/70	U	0.65	0.15	0.17	1.51
1000	L	0.74	0.08	0.15	1.87
30/0/70	U	1.21	0.15	0.16	1.91
2000	L	1.22	0.11	0.11	1.56
2/20/78	U	0.61	0.06	0.09	1.62
1000	L	0.95	0.05	0.06	2.46
2/20/78	U	0.59	0.09	0.15	0.89
2000	L	0.73	0.08	0.08	0.80
15/52/33	U	1.08	0.24	0.26	1.72
1000	L	1.03	0.17	0.10	1.47
15/52/33	U	0.92	0.38	0.39	0.87
2000	L	0.63	0.27	0.30	0.65

10. Acid-Base Balance

In the study of acid-base balance only a few selected important aspects were covered. These were the total titrable acidity and pH of the urine. (Table III. 39 and Figure III. 19), the production of ketone bodies (Tables III. 40 and III. 41), and the urinary excretion of ammonia (Table III. 42). As is well known, the acid-base balance of the body is affected primarily by two major factors: (1) exogenous addition of acid or alkaline substances to the body, and (2) endogenous production or retention of acid or alkaline substances. It was not anticipated that our subjects would develop pathological metabolic or respiratory acidosis or alkalosis, but it was expected that they would show striking changes as a result of calorie deficiency and imbalance of the protein/carbohydrate/fat ratio of the nutrient mixtures. These expectations were borne out by the events.

The urinary titrable acidity is a measure of the total excess of acid to alkali in the body together with the acid-base adjustment made by the kidney itself, and the pH is correlated in general with the relative excess of acid to alkali. In our subjects in pre-periods the titrable acidity was in the range usually considered

TABLE III. 29

URINARY EXCRETION OF CALCIUM
(Mean and Range, mg/24hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	256	192	213	267
	102-436	108-297	103-277	105-434
ST 0	240	172	129	330
	202-305	88-222	73-216	229-434
0/100/0	235	82	26	266
1000	163-297	26-164	10-46	193-393
0/100/0	103	70	42	203
2000	125-255	44-108	22-52	223-358
2/20/78	253	96	102	390
1000	147-318	58-135	83-119	330-451
2/20/78	202	81	106	248
2000	171-234	64-98	75-137	227-268
15/52/33	290	80	80	310
1000	156-422	62-123	54-101	102-401
15/52/33	322	152	150	277
2000	140-468	94-240	102-233	193-413
30/0/70	256	136	187	300
1000	231-282	126-145	---	358-401
30/0/70	294	100	170	430
2000	252-332	84-117	146-195	376-486

normal (15-30 mEq/day) as was the average pH (6.1-6.6). These data are shown in Table III. 39. Figure III. 19 demonstrates that there was generally an increase in the titrable acidity and a decrease in urinary pH in all experimental periods, these changes tending to reverse in recovery periods. The changes during experimental periods were most striking under conditions when one would expect metabolic acidosis to be present (e.g., the ketosis of starvation and high fat-low carbohydrate diets). Thus, the greatest changes were observed in starvation and in 30/0/70 2000.

Metabolism of ketone bodies is a very important area for study in relation to survival rations. There is extensive literature on this subject, both from the clinical standpoint, as in diabetes mellitus, and for normal, healthy conditions, as in the study of ketogenic diets, the ketosis of exercise, and the ketosis of exposure to cold. It is not yet proved, but is probable, that chronic dietary ketosis in healthy men is potentially deleterious to some kinds of organ functions and overall efficiency. Therefore our findings in this respect are of considerable importance in assessing the merits of the several nutrient mixtures.

STAT

TABLE III. 30

FECAL CALCIUM
(mg/day)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	548	372	378	817
	179-720	265-470	222-620	303-1142
ST 0	405	55	62	1324
	189-665	20-110	27-110	700-2385
0/100/0	712	140	194	1242
1000	372-1447	90-260	72-307	630-1882
0/100/0	788	150	228	1466
2000	680-985	90-262	117-402	1077-1767
2/20/78	467	231	231	1740
1000	372-562	112-350	112-350	1482-1997
2/20/78	918	178	342	724
2000	805-1032	13-342	---	567-882
15/52/33	646	268	448	1122
1000	372-967	55-477	285-610	690-1525
15/52/33	374	245	206	484
2000	234-670	162-320	180-257	304-642
30/0/70	458	136	217	1051
1000	422-495	55-217	---	920-1182
30/0/70	750	255	225	1098
2000	580-920	185-325	185-265	855-1340

Qualitative tests for urinary acetone bodies showed that strong positive results never occurred in the pre-periods, recovery periods, normal control periods, experimental periods for pure carbohydrate, or experimental periods for the normal mixture. Strong positives were detected in starvation and in the 30/0/70 2000 periods. Lesser amounts were detected during the 30/0/70 1000 periods and when 2/20/78 was employed (Table III. 40). When quantitative measurement was made of urinary excretion of acetone alone (Table III. 41); i.e., no measurement of acetoacetic acid and beta hydroxybutyric acid, the same general results were found as for the qualitative tests. That is to say, acetonuria was pronounced only in starvation and in the 30/0/70 periods. Whenever carbohydrate was present in the nutrient mixture, acetonuria was moderate or absent. In general, also, an increase of calories reduced the acetonuria, regardless of the FRO/CHO/Fat ratio of the survival ration.

We conclude that the meat bar ration; the chocolate bar ration, and starvation are all ketogenic in greater or lesser degree. We conclude also that at 1000 Calories, the ketosis of starvation may be present together with the ketogenic effects of the nutrient mixture itself. At 2000 Calories, the ketogenic effect of the nutrient mixture is seen alone.

TABLE III. 31

CALCIUM BALANCE

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
		gm/day	gm/day	gm/day	gm/day
N 3000	U	+0.28	-0.02	-0.03	+0.04
	L	-0.37	-0.15	-0.11	-0.03
ST 0	U	-0.04	-0.16	-0.10	-0.22
	L	-0.13	-0.18	-0.18	-0.23
0/100/0	U	-0.05	-0.12	-0.03	-0.23
1000	L	-0.32	-0.17	-0.04	+0.00
0/100/0	U	-0.09	-0.05	-0.17	-0.19
2000	L	-0.21	-0.25	-0.18	-0.20
2/20/78	U	+0.12	-0.35	-0.32	+0.00
1000	L	-0.07	-0.19	-0.17	+0.01
2/20/78	U	-0.49	0.00	-0.07	-0.16
2000	L	-0.47	-0.35	-0.27	+0.07
15/52/33	U	-0.10	-0.[illegible]	-0.37	+0.54
1000	L	+0.34	-0.22	-0.33	-0.18
15/52/33	U	+0.44	-0.02	+0.05	-0.19
2000	L	+0.01	-0.10	-0.06	+0.06
30/0/70	U	-0.01	-0.21	-0.22	+0.23
1000	L	-0.03	-0.10	-0.17	+0.29
30/0/70	U	-0.13	-0.26	-0.30	+0.07
2000	L	+0.31	-0.19	-0.22	-0.16

Urinary excretion of ammonia is another feature of acid-base balance. Teleologically speaking, ammonia is formed by the kidney in response to increasing acidity, and is excreted in association with acidic radicals. Thus, it conserves fixed base at times when fixed base would otherwise have to be excreted. Urinary ammonia, being produced by the tubules, is also in some way related to the tubular functions of the kidney. Finally, urinary ammonia is excreted roughly in proportion to the total nitrogen intake, as it is one of the end products of protein metabolism.

In view of the complexities of ammonia metabolism, it is not surprising that the data presented in Table III. 42 are not easy to interpret in simple terms. The salient features probably are two. First, with increasing protein intake, there tended to be an increased excretion of ammonia. It will be seen that the excretion tended to be high in pre-periods, recovery periods, the 30/0/70 periods, and the positive control periods. In addition, during the two experimental regimens when ketonuria was most pronounced, urinary ammonia excretion was higher than at any other times.

To summarize the observations on acid-base balance presented in this section, there is a definite correlation between the

STAT
STAT

urinary acid, ketone body, and ammonia excretion in relation both to absolute calorie intake and with respect to protein/carbohydrate/fat ratios in the diet. When the caloric intake was 2000 or above, and there was a substantial percentage of carbohydrate, acid-base balance was least disturbed.

11. Carbohydrate and Fat Intakes

Under the conditions of our experiment, it is not possible to use the concept of balance with respect to carbohydrate and fat, nor even to determine the carbohydrate and fat turnover. Hence, only the gross intakes will be presented, for carbohydrate in Table III. 43 and for fat in Table III. 44.

Carbohydrate intake ranged from 360 gm/day to 585 in pre-periods, and from 377 to 729 in recovery periods. During experimental periods it was set by dietetic considerations at levels variously between 0 gm/day and 514. By comparison between recovery periods and pre-periods one can arrive at a rough correlate of "carbohydrate craving" induced by the intervening experimental conditions. Two interesting generalizations emerge. First, when the experimental periods allowed 2000 Calories or more, there was little "carbohydrate craving" in the recovery period. Second, at 1000 Calories or less there developed a "carbohydrate craving" if the experimental carbohydrate allowance was 50 gm or less, but not if it were 130 gm or over. It might be concluded that insofar as one's appetite is concerned, the preferential form of calories in extreme caloric deprivation is carbohydrate, but not in mild calorie deprivation.

So far as fat is concerned (Table III. 44), the intake for pre-periods ranged from 105 to 172 gm/day, and for recovery periods from 96 to 280. These wide ranges correlate in part with the subjects' preferences for fat as a normal part of their usual diets. In experimental periods, the intakes were set at values ranging from 0 to 174 gm/day.

CAPTION FOR FIGURES III. 13 and III. 14
CALCIUM BALANCE I and II

Ordinates: Calcium Gain and Loss in Grams/Day
Left Bar (Gain) Right Bar (Loss)
Vertical Lines - Dietary Intake Blank - Urinary Excretion
Horizontal Lines - Fecal Loss

Abscissae: Periods of Experiment
PRE - Week Prior to Experimental Periods
EXP - First and Second Week of Experimental Periods
REC - Week after Experimental Periods

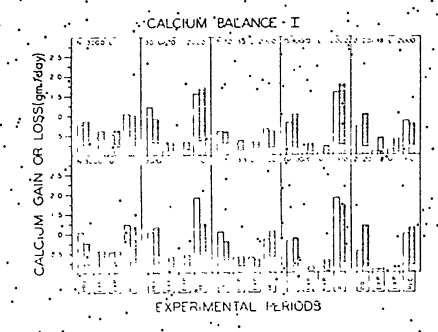

FIGURE III. 13

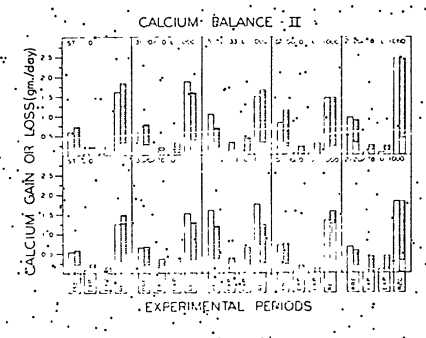

FIGURE III. 14

STAT

TABLE III. 32

AVERAGE DAILY PHOSPHATE INTAKE
(gm P/day)

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
M 3000	U	1.45	1.20	1.21	1.82
	L	1.52	1.18	1.57	1.43
St 0	U	1.28	0.00	0.00	1.83
	L	1.53	0.00	0.00	2.19
0/100/0	U	1.39	0.00	0.00	1.93
1000	L	1.71	0.00	0.01	2.03
0/100/0	U	1.61	0.00	0.07	2.01
2000	L	1.69	0.00	0.04	2.17
30/0/70	U	1.50	0.59	0.59	2.44
1000	L	1.73	0.59	0.66a	2.61
30/0/70	U	2.01	1.19	1.19	2.44
2000	L	1.91	1.19	1.19	2.12
2/20/78	U	1.25	0.08	0.14	2.07
1000	L	1.81	0.08	0.13	3.20
2/20/78	U	1.45	0.25	0.27	1.68
2000	L	1.79	0.33	0.08	1.47
15/52/33	U	2.01	0.67	0.43	2.43
1000	L	1.87	0.67	0.67	2.17
15/52/33	U	1.80	1.40	1.05	1.58
2000	L	1.26	1.30	1.28	1.53

aAdded 1000 Cal/day of carbohydrate

When one searches for a "fat craving" in the recovery periods, it is not evident in starvation, but is evident for two experimental conditions, if one judges by the difference between recovery and pre-periods. It was present in 30/0/70 1000 and 2/20/78 1000. In other words, it appeared only at a level of acute caloric deprivation after periods in which the percentage of calories in carbohydrate was very low. We have no hypothesis to offer concerning this finding.

C. BODY COMPOSITION

1. Body Weight

The changes in body weight experienced by the subjects during subsistence on the experimental nutrient mixtures are summarized in Table III. 45 and Figure III. 20. Data on the daily weights are detailed in Appendix II.

TABLE III. 33

URINARY EXCRETION OF PHOSPHATE
(Mean and Range, gm P/24hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
M 3000	1.04	1.07	0.96	1.07
	0.77-1.26	0.78-1.28	0.79-1.26	0.74-1.48
St 0	1.17	1.07	0.64	0.88
	0.96-1.39	0.70-1.43	0.51-0.72	0.72-1.13
0/100/0	1.08	0.57	0.50	0.83
1000	0.87-1.42	0.48-0.73	0.43-0.60	0.67-0.98
0/100/0	1.02	0.48	0.32	1.12
2000	0.90-1.16	0.40-0.62	0.21-0.38	1.02-1.21
30/0/70	1.04	0.47	0.50	0.76
1000	0.98-1.10	0.66-0.88	0.47-0.51	0.53-0.99
30/0/70	1.20	0.64	0.72	0.88
2000	1.19-1.22	0.63-0.66	0.63-0.82	0.72-1.05
2/20/78	1.08	0.88	0.79	1.09
1000	0.91-1.31	0.79-0.99	0.67-0.81	0.72-1.37
2/20/78	1.60	1.15	1.04	1.03
2000	0.63-1.34	1.00-1.39	0.81-1.31	0.77-1.27
15/52/33	1.19	1.32	1.04	1.02
1000	1.15-1.23	1.28-1.36	0.98-1.11	0.89-1.15
15/52/33	0.90	1.39	1.34	1.03
2000	0.33-0.96	1.32-1.46	1.15-1.53	0.65-1.21

The limits of weight loss were set by positive and negative control. On none of the other diets did the subjects' loss of weight fall outside these limits. On unlimited water the loss ranged from 0.7 kg during positive control to 7.2 kg during negative control. On limited water the losses were 2.9 and 7.6 kg, respectively. More weight was lost during the regimen in which water was limited even when the subjects were in caloric balance. These limits indicate the two general types of weight loss observed in the subjects: (1) loss due to negative water balance and (2) loss due to catabolism of body substance when the caloric balance was negative. On most of the dietary regimens the observed weight loss was attributable to both processes.

Limited Water. Examination of the data indicates that on most diets, the subjects on limited water lost more weight than those on unlimited water. The only exception was 15/52/33 2000. In this instance both of the subjects on limited water had to be withdrawn from the diet early because of severe clinical symptoms. The magnitude of the difference in weight loss between the two regimens of water varies and shows no consistent relationship to solute load. The solute loads of the 0/100/0 and 2/20/78 mixtures were much smaller than those of the 15/52/33 and 30/0/70 mixtures. The latter

STAT
STAT

TABLE III. 34

FECAL PHOSPHORUS
(gm P/day)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	0.49	0.39	0.38	0.50
	0.18-0.71	0.21-0.78	0.33-0.47	0.26-0.78
ST 0	0.36	0.07	0.07	0.82
	0.21-0.45	0.04-0.09	0.05-0.09	0.51-1.47
0/100/0	0.57	0.09	0.19	0.80
1000	0.37-1.04	0.08-0.18	0.08-0.27	0.44-1.46
0/100/0	0.52	0.14	0.19	0.93
2000	0.32-0.74	0.09-0.20	0.09-0.29	0.62-0.99
2/20/78	0.40	0.08	0.08	1.12
1000	0.37-0.43	0.04-0.12	0.04-0.12	0.82-1.41
2/20/78	0.55	0.08	0.15	0.44
2000	----	0.01-0.15	----	0.34-0.54
15/52/33	0.52	0.12	0.30	0.80
1000	0.34-0.92	0.04-0.17	0.17-0.43	0.54-1.14
15/52/33	0.30	0.36	0.47	0.36
2000	0.17-0.56	0.28-0.42	0.18-0.97	0.22-0.43
30/0/70	0.44	0.10	0.14	0.82
1000	0.39-0.50	0.06-0.14	----	0.68-0.97
30/0/70	0.50	0.18	0.16	0.75
2000	0.34-0.66	0.10-0.17	0.10-0.21	0.62-0.88

theoretically should be more thirst-provoking, a property which might reasonably be expected to accentuate the difference. One consistent reaction to regimens with a low solute load was a reduction in the voluntary consumption of water by subjects on unlimited water. Frequently, as a result of this reduction, the voluntary intake approached the 900-ml level set for limited water. This phenomenon has been discussed above in the section dealing with Water Balance.

Attention is called to an interesting phenomenon in Figures III. 20 and 21: the subjects on limited water did not lose weight from day to day at a constant rate, rather the weight loss became progressively less and less so that during the second week these men tended to come into equilibrium. Similar phenomena have been noted above in the case of caloric balance, water balance, nitrogen balance, and the mineral balances. In effect, the subjects seem to adjust to a new level of functional activity, a process which represents a broad homeostatic adjustment.

Caloric Intake. Regardless of water intake the subjects lost more weight during periods of subsistence at 1000 Cal/day than at

TABLE III. 35

AVERAGE PHOSPHATE BALANCE DURING EXPERIMENTAL REGIMENS

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
		gm/day	gm/day	gm/day	gm/day
N 3000	U	-0.11	-0.28	-0.11	+0.28
	L	+0.01	-0.25	+0.21	-0.15
ST 0	U	-0.17	-1.12	-0.65	+0.23
	L	-0.17	-1.15	-0.77	+0.42
0/100/0	U	-0.17	-0.57	-0.50	+0.13
1000	L	-0.15	-0.75	-0.77	+0.43
0/100/0	U	+0.07	-0.24	-0.48	+0.13
2000	L	+0.07	-0.69	-0.63	+0.14
2/20/78	U	-0.10	-0.67	-0.45	+0.4
1000	L	+0.28	-0.84	-0.15	+0.80
2/20/78	U	-0.42	-0.52	-0.50	+0.43
2000	L	-0.05	-0.34	-0.15	-0.02
15/52/33	U	+0.25	-0.38	-0.69	+0.67
1000*	L	+0.10	-0.27	-0.26	+0.29
15/52/33	U	+0.43	-0.19	-0.19	-0.12
2000	L	+0.05	-0.15	-0.49	+0.27
30/0/70	U	-0.17	-0.91	-0.66	+0.77
1000	L	+0.08	-0.75	-0.513	+0.49
30/0/70	U	+0.39	-0.44	-0.55	+0.61
2000	L	+0.74	-0.23	+0.06	+0.39

*Added 1000 Cal/day of carbohydrate

2000 Cal/day. Again a tendency for the rate of weight loss to approach zero during the second week was evident (Figure III: 20), the trend being more striking in the case of men at 2000 Cal/day than at 1000 Cal/day. On starvation the men lost weight rapidly each day and there was little tendency for the rate of weight loss to decrease.

Nutrient Mixture: Other variables (caloric and water balance) being reasonably constant, there were differences in the total weight losses in relation to the experimental nutrient mixture. At both 1000 Cal/day and 2000 Cal/day there was a smaller weight loss by men subsisting on 15/52/33 than on the other three dietary regimens.

1000 Cal/day: In this case the weight losses were 5.7, 5.5, and 5.3 kg for 0/100/0, 30/0/70, and 2/20/78, respectively, when the water was unlimited. When the water was limited, the losses were 6.5, 6.4, and 6.7 kg, respectively. On 15/52/33 U the weight loss was 4.2 kg; L, 5.4. Regardless of the water intake, then, the

STAT
STAT

not conservation of body substance on the latter regimen was of the order of 1.0 kg.

2000 Cal/day: At this level of caloric intake the weight losses were 4.5, 4.6, and 3.9 kg for 0/100/0, 30/0/70, and 2/20/78, respectively, when the water was unlimited. When the water was limited, the losses were 5.2, 4.8, and 5.5 kg, respectively. On 15/52/33 U the weight loss was 3.6 kg; L, 3.3 kg. Again the net conservation of tissue was about 1.0 kg.

Although one cannot explain this result fully, analysis of the curves of weight loss shows that the men tended to come into equilibrium more rapidly on 15/52/33 than on other dietary regimens. This nutrient mixture thus promotes or facilitates the homeostatic adjustments which the body under stress is capable of making. Additional evidence will be presented elsewhere in this report that the 15/52/33 regimen caused the least functional aberrations in ... most of the organs and systems studied.

The Pre-Period. The mean daily weight of the subjects was remarkably constant during each of the five pre-periods (Table III. 46). One subject (No. 3) lost 4.0 kg and two (No. 7 and 8) gained 1.9 and 2.5 kg, respectively, between the first and last pre-period. The other subjects showed little net change. Data for Subject 4. are not given since he was on the investigation for only one pre-period. The general constancy of the weight suggests that the men returned to a reasonably uniform level after each experimental period and that the recovery period of seven days was sufficiently long for almost complete rehabilitation. The failure of any consistent trend to appear in these data indicates that although the men began to tire of the 5-in-1 control ration, they nevertheless continued to eat it in sufficient amounts to maintain their body weight. By developing new recipes for the several components and by the use of supplements (fresh bread, oleomargarine, ice cream, and orange juice), the meals were made sufficiently attractive and appetizing, so that gross habituation did not become serious,

CAPTION FOR FIGURES III. 15 and III. 16
PHOSPHORUS BALANCE I and II

Ordinates: Phosphorus Gain or Loss in Grams/Day
Left Bar (Gain) Right Bar (Loss)
Vertical Lines - Dietary Intake
Blank - Urinary Excretion
Horizontal Lines - Fecal Loss

Abscissae: Periods of Experiment
PRE - Week Prior to Experimental Periods
EXP - First and Second Weeks of Experimental Periods
REC - Week after Experimental Periods

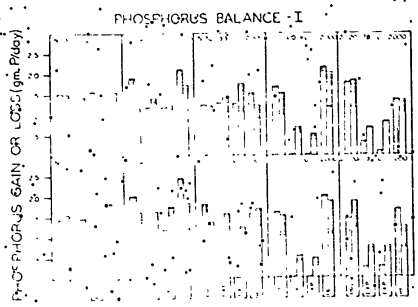

FIGURE III. 15

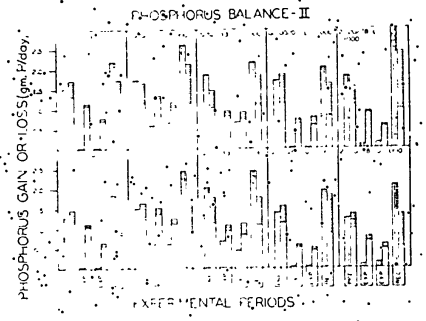

FIGURE III. 16

STAT
STAT

TABLE III. 36

AVERAGE DAILY CHLORIDE INTAKE
(gm Cl/day)

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	U	15.0	11.0	10.8	11.8
	L	13.4	10.2	10.7	8.9
ST 0	U	12.6	0.0	0.0	13.0
	L	13.1	0.0	0.0	13.7
0/100/0 1000	U	14.7	0.0	0.0	11.9
	L	14.4	0.0	0.1	12.9
0/100/0 2000	U	13.0	0.0	0.4	11.5
	L	12.0	0.1	0.2	10.2
30/0/70 1000	U	15.3	0.0	0.0	15.3
	L	17.3	0.0	4.0a	15.6
30/0/70 2000	U	12.7	0.1	0.1	12.4
	L	15.3	0.1	0.1	13.0
2/20/78 1000	U	12.6	0.0	1.9	13.9
	L	14.9	0.0	1.7	13.8
2/20/78 2000	U	17.0	0.2	0.4	13.4
	L	13.9	0.2	0.2	11.4
15/52/33 1000	U	15.9	0.3	0.4	12.3
	L	13.5	0.3	0.3	11.7
15/52/33 2000	U	14.2	1.7	2.6	13.7
	L	11.9	1.7	2.2	7.5

a added 1000 Cal/day of carbohydrate

2. Body Water

Of the several measurements of body water only data for antipyrine space and D_2O space will be presented here. These data are summarized in Table III. 47 and Figures III. 21 and 22. The detailed results are given in Appendix II. Our data on thiosulfate space are still incomplete; they will not be reported here.

Control data for antipyrine space were obtained from determinations on the regular and alternate subjects. Prior to the determinations the regular subjects had recovered from the effects of a preceding experimental regimen; such measurements were made in the pre-period. The alternate subjects were tested when they had been subsisting on their usual diet for at least 10-14 days. In nine tests the antipyrine space averaged 37.3 liters or 54.2% of the body weight. The range was 33.6-47.3 l or 46.5-59.0% of the body weight. Two additional determinations were made on subjects late in the second week of positive control (unlimited water). The mean of 35.0 l (or 50.6% of body weight) was within the range established by the nine control tests.

TABLE III. 37

URINARY EXCRETION OF CHLORIDE
(Mean and Range, gm NaCl/24hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	19.6 11.8-27.4	14.8 10.3-15.5	14.3 10.0-16.3	18.4 9.5-27.8
ST 0	15.2 13.5-21.0	2.7 1.6-3.5	0.2 0.0-0.7	20.9 1[illegible]-29.3
0/100/0 1000	20.0 10.3-23.8	[illegible].0 [illegible]-2.8	0.1 0.0-0.5	20.3 1[illegible]-25.2
0/100/0 2000	15.9 13.[illegible]-25.2	2.9 1.2-7.0	[illegible].0 -----	15.9 13.0-20.9
2/20/78 1000	21.3 [illegible]0.5-23.0	2.1 1.6-2.6	1.2 [illegible]	2[illegible].7 [illegible]-25.2
2/20/78 2000	15.5 1[illegible].6-19.0	[illegible].5 [illegible].0-7.0	[illegible].9 [illegible].6-5.2	15.1 13.3-16.9
15/52/33 1000	21.0 [illegible]-2[illegible].5	2.6 2.1-3.0	1.0 [illegible]	1[illegible].7 1[illegible]-2[illegible].5
15/52/33 2000	17.5 1[illegible].6-19.[illegible]	[illegible].5 3.0-6.0	[illegible].5 2.0-[illegible].3	[illegible].3 [illegible].3-21.9
30/0/70 1000	22.5 20.[illegible]-2[illegible]	[illegible] [illegible].5-5.2	1.4 -----	21.5 [illegible]1.2-[illegible]1.8
30/0/70 2000	21.5 [illegible].7-23.4	5.0 5.9-6.1	2.[illegible] [illegible]-3.3	1[illegible] 1[illegible].3-19.2

Water Intake. The subjects [illegible] on limited water consistently [illegible] a decrease in the volume of the antipyrine space. The reduction [illegible] ranged from [illegible].7 to 1[illegible].2 l. Less consistent trends were evident when the spaces were expressed as a percent of the body weight. Values within the control range were observed in the case of ST 0, 0/100/0 1000, 15/52/33 1000 and 2/20/78 1000. Values outside this range were observed in the cases of 0/100/0 2000 and 30/0/70 1000. A possible interpretation of these results is that body water and body weight were being lost at approximately the same rate by men subsisting on the former diets. Such was seen in the case of the subject measured while on 0/100/0 2000, where the net reduction in percent of body water was small. In the case of subjects on 30/0/70 1000, there was [illegible] initial determination [illegible] which could not be attributed to [illegible] body water was [illegible] below [illegible] Here the reduction in percent of body water [illegible] from a special lower control level. These data were obtained [illegible] subjects. The antipyrine space [illegible] on the [illegible] subsisting on the [illegible] was not measured on subject [illegible] at the time he was [illegible]; therefore, the above suggested explanation of this condition was not directly established.

STAT
STAT

TABLE. III. 38

AVERAGE CHLORIDE BALANCE DURING EXPERIMENTAL REGIMENS

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
		gm/day	gm/day	gm/day	gm/day
N 3000	U	+1.5	+1.7	+1.2	-0.9
	L	+3.0	+1.5	+3.0	+0.8
ST 0	U	+2.1	-1.9	-0.4	+0.7
	L	+1.5	-1.4	-0.1	+1.5
0/100/0	U	+2.7	-1.1	0.0	-0.4
1000	L	+2.3	-1.3	-0.1	+0.6
0/100/0	U	+2.4	-0.9	+0.4	+0.6
2000	L	-0.1	-2.5	+0.2	+1.3
2/20/78	U	-0.2	-1.6	+0.8	-1.4
1000	L	+1.0	-1.0	+1.4	-0.9
2/20/78	U	+3.3	-1.5	-0.3	+1.0
2000	L	+2.6	-1.3	-0.2	+1.3
15/52/33	U	+1.8	-1.1	-0.1	+0.9
1000	L	+2.1	-1.4	-0.3	+0.7
15/52/33	U	+3.3	-1.1	+0.1	+0.4
2000	L	+1.6	-1.0	-1.1	+1.1
30/0/70	U	+3.1	-2.1	-0.8	+2.1
1000	L	+2.4	-3.3	+1.2*	+2.7
30/0/70	U	+0.8	-3.6	-1.6	+1.3
2000	L	+1.1	-3.4	-0.7	+1.4

*Added 1000 Cal/day of carbohydrate

CAPTION FOR FIGURES III. 17 and III. 18
CHLORIDE BALANCE I and II

Ordinates: Chloride Gain or Loss in Grams/Day
Left Bar (Gain) Right Bar (Loss)
Vertical Lines - Dietary Intake
Blank - Urinary Excretion

Abscissae: Periods of Experiment
PRE - Week Prior to Experimental Periods
EXP - First and Second Week of Experimental Periods
REC - Week after Experimental Periods

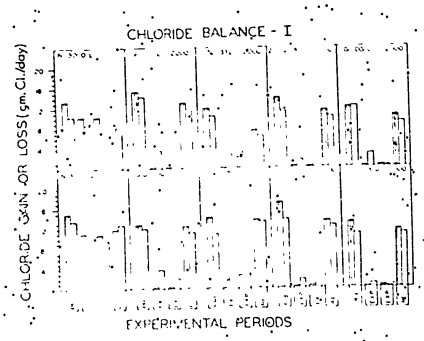

FIGURE III. 17

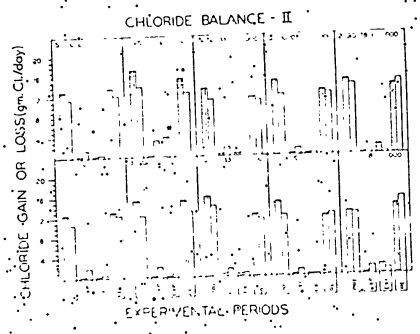

FIGURE III. 18

TABLE III. 39

PRE-PERIOD DATA ON URINARY TITRABLE ACIDITY AND pH

Subject No.	Titrable Acidity Mean	Titrable Acidity Range	pH Mean	pH Range
	mEq/24 hr			
1	15.0	4.3-21.7	6.6	5.7-7.0
2	18.2	10.7-24.7	6.4	6.0-6.6
3	26.7	15.8-42.4	6.1	5.6-6.5
4	29.2	23.3-42.5	6.1	6.0-6.5
5	20.0	7.5-33.6	6.2	5.7-6.6
6	25.8	14.8-45.9	6.1	5.9-6.6
7	23.5	17.6-29.5	6.4	6.2-6.6
8	17.4	4.8-29.3	6.5	6.2-7.0
12	17.4	9.8-37.6	6.4	5.8-6.7

Turning to the data from subjects on unlimited water, we find that three diets were associated with substantial reductions in body water: 0/100/0 1000, 9.6 l; 2/20/78, 5.0 l, and 30/0/70 1000, 8.8 l. On only two of these regimens, however, did the body water, expressed as percent of body weight, also decrease: 0/100/0 1000 and 30/0/70 1000. In both instances the decreases were quite comparable to those observed for subjects on limited water. In the case of the pure carbohydrate regimen, the decrease may have been due to voluntary dehydration provoked by the low thirst-provoking qualities of the diet. The interesting observation is that the men on meat bar and unlimited water lost as much body water as did those on limited water. This fact raises considerable doubt regarding dehydration as the specific cause of the clinical deterioration observed in the men on limited water.

Caloric Intake. In spite of the limited data available, it is doubtful that caloric intake per se influenced the body water. More striking alterations were observed in the case of the 1000 Cal/day regimens than in the case of starvation. The values for men at 2000- and 3000 Cal/day were within the expected (control) range.

Nutrient Mixture. The effect of the nutrient mixtures has been discussed above. The most interesting observations were made in connection with the carbohydrate and meat bar diets at 1000 Cal/day. Here the reductions in antipyrine space were independent of water intake and the data suggested that water was lost from the body at a greater rate than was total body substance. The trends hold whether the values in the experimental periods are compared with the control data (Table III. 47) or with the subject's own control datum (Figures III. 21 and 22). The striking results suggest a specific effect for these two mixtures on the total water

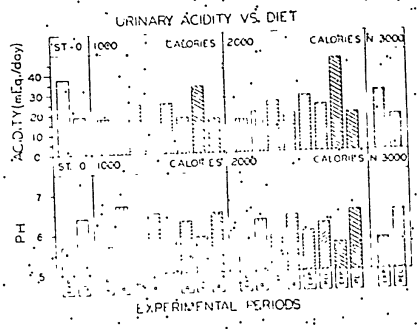

FIGURE III. 19. URINARY ACIDITY VS. DIET.

Ordinates: Titrable Acidity in mEq/Day and pH

Code for Bars:

Blank - ST 0
Vertical Lines - 0/100/0
Horizontal Lines - 2/20/78
Diagonal Lines (to right) - 15/52/33.
Diagonal Lines (to left) - 30/0/70
Solid Black - N 3000

Abscissae: Periods of Experiment

EXP - Mean of Both Weeks of Experimental Periods
REC - Week after Experimental Period

STAT

TABLE III. 40

URINALYSIS: KETONURIA*
(Qualitative)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	(29) 0(29)	(24) 0(24)	(24) 0(24)	(22) 0(22)
ST 0	(40) 0(40)	(24) 0(3) tr(1) 1+(12) 2+(3) 3+(3) 4+(2)	(10) 0(1) tr(2) 1+(1) 2+(4) 3+(1) 4+(1)	(23) 0(23)
0/100/0 1000	(12) 0(12)	(12) 0(12)	(12) 0(12)	(12) 0(12)
0/100/0 2000	(12) 0(12)	(12) 0(12)	(12) 0(12)	(12) 0(12)
2/20/78 1000	(6) 0(6)	(6) 1+(4) 0(2)	(5) tr(4) 0(1)	(6) 0(6)
2/20/78 2000	(6) 0(6)	(6) tr(1) 1+(1) 0(4)	(4) 2+(1) 0(3)	(6) 0(6)
15/52/33 1000	(12) 0(12)	(12) 0(12)	(12) 0(12)	(12) 0(12)
15/52/33 2000	(18) 0(18)	(11) 0(11)	(10) 0(10)	(12) 0(12)
30/0/70 1000	(6) 0(6)	(6) tr(2) 2+(3) 3+(1)	(5) tr(1) 3+(2)	(5) 0(0)
30/0/70 2000	(5) 0(5)	(6) tr(1) 1+(2) 2+(2) 4+(1)	(6) 0(3) 2+(1) 3+(2)	(5) 0(5)

* Numbers in parentheses indicate number of specimens examined (upper left corner) or number giving particular reaction.

content of the body. The mechanisms involved are probably different and only further detailed investigation will define them.

Comment. The interpretation of these results rests on two major assumptions: (1) that the antipyrine space is a reliable measure of the total body water and (2) that the metabolism and distribution of antipyrine in the water of the body is the same in the dehydrated man as in the hydrated man. The evidence for the reliability of antipyrine as a measure of total body water has been discussed in Section II. For the healthy man or experimental animal the results are very similar whether body water is measured by D_2O or antipyrine. For the second assumption the grounds are weaker. Very few direct measurements (Quinn et al.,

TABLE III. 41

URINARY ACETONE
(Mean and Range, mg/24hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	7.2 0-17.5	1.1 0-6.7	3.4 0-20.1	6.5 0-26.8
ST 0	4.4 0-21.0	215.2 0-386.0	88.9 55.8-122.0	1.4 0-11.5
0/100/0 1000	16.7 0-39.5	2.5 0-7.7	0.9 0-3.7	0.0 ---
0/100/0 2000	2.4 0-9.6	0.0 ---	0.0 ---	--- ---
2/20/78 1000	--- ---	91.0 ---	21.4 ---	19.4 17.9-20.9
2/20/78 2000	10.2 0-20.3	9.6 4.8-14.5	0.0 ---	9.6 5.9-13.4
15/52/33 1000	5.1 0-20.4	9.3 0-19.5	3.4 0-6.8	0.0 ---
15/52/33 2000	7.8 0-15.9	0.0 ---	0.0 ---	4.8 0-14.5
30/0/70 1000	0.0 ---	201.0 107.0-301.0	301.0 ---	0.0 ---
30/0/70 2000	0.0 ---	73.7 47.4-100.0	96.9 17.9-159.0	0.0 ---

1953a,b) of body water have been made on the chronically dehydrated man or even experimental animals. Most of the data on body water in the dehydrated organism has been based on calculations from changes in sodium or chloride balance. That the metabolism of antipyrine may be disturbed by deviations from normal of the body water can be inferred from published studies on edematous patients. In such patients (Keys and Brožek, 1953) unreliable values are obtained because antipyrine equilibrates so slowly with the edema fluid. An analogous situation may develop in the dehydrated subject.

Comparison of D_2O and antipyrine spaces. Opportunity was afforded in the present study for twelve comparisons of D_2O and antipyrine spaces under a variety of dietary and hydremic conditions (Table III. 6): When the data were calculated in terms of liters the D_2O space was the larger in 10 of the 12 simultaneous comparisons and the general difference was of the order of 10%. When the results in "% body wt," the D_2O space was the larger in the same 10 cases, the figure being of the order of 6% of the body weight. It is probable that the D_2O method is the more reliable as inspection of the data for Subjects 9 and 11 (special experiment on 72

TABLE III. 42

URINARY AMMONIA NITROGEN
(Mean and Range, mg/2hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	70.8	46.1	52.8	42.0
	35.1-162.3	22.8-62.4	42.3-64.4	41.0-43.9
ST 0	----	----	----	----
	----	----	----	----
0/100/0	42.2	28.9	15.5	54.7
1000	36.6-47.7	26.8-32.6	3.0-30.8	24.5-68.8
0/100/0	69.1	34.1	35.2	80.7
2000	58.2-78.6	27.1-41.7	28.3-45.7	39.5-118.3
2/20/78	15.3	57.2	30.6	40.4
1000	6.6-24.0	55.7-58.7	24.7-36.6	33.8-47.0
2/20/78	48.8	38.5	34.7	61.6
2000	43.3-54.2	33.1-43.9	33.5-35.8	56.8-66.5
15/52/33	51.2	38.8	40.4	55.3
1000	23.0-78.6	23.6-47.6	35.6-49.0	30.0-79.7
15/52/33	38.4	22.7	31.6	----
2000	21.5-55.3	20.4-25.0	17.9-45.3	----
30/0/70	----	126.0	70.0	33.0
1000	----	124.0-128.0	60.0-80.0	31.3-34.7
30/0/70	48.5	94.0	72.8	62.1
2000	25.0-72.0	75.0-113.0	69.6-76.1	27.3-96.9

hours of acute dehydration described in detail in Appendix II) will show. During starvation with unlimited water one would theoretically expect a larger body water than with starvation and total abstention from water. This expectation was well met by the D_2O space but in Subject 9 the antipyrine space was the reverse of expectation. Two conclusions can be drawn: (1) D_2O space and antipyrine space are of the same order of magnitude. (2) Under conditions of known acute dehydration, the D_2O space correlates very well with degree of dehydration. Finally, if a choice is to be had, body water should be measured by D_2O both because the measurements seem to be more reliable and the technics certainly are simpler.

Water Diuresis Test. The results of the water diuresis tests are summarized in Figures III. 23 and 24. The detailed data are given in Appendix II. These figures represent the percentage of the water load which was recovered in the urine during four hours after a standard dose (20 ml/kg). This recovery was calculated as described in detail in Section II. The black area represents the extent of the correction made for the basal urine flow. Several of

TABLE III. 43

AVERAGE DAILY CARBOHYDRATE INTAKE

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery	(Rec-Pre)
		gm/day	gm/day	gm/day	gm/day	gm/day
N 3000	U	474	352	342	484	10
	L	447	348	341	393	-54
ST 0	U	390	0	0	482	122
	L	370	0	0	560	190
0/100/0	U	446	252	252	486	40
1000	L	419	252	255	497	27
0/100/0	U	437	509	514	435	0
2000	L	464	504	476	501	37
30/0/70	U	491	0	0	729	238
1000	L	550	0	262	705	155
30/0/70	U	531	0	0	563	32
2000	L	595	0	0	549	-36
2/20/78	U	557	52	50	594	235
1000	L	485	52	51	628	143
2/20/78	U	360	99	53	377	17
2000	L	370	84	23	436	66
15/52/33	U	523	133	148	535	12
1000	L	512	130	130	566	54
15/52/33	U	399	234	253	415	26
2000	L	413	239	267	346	-67

the uncorrected recoveries exceeded 100%; none of the corrected recoveries did.

Water Intake: The most striking alterations in the percent of recoveries occurred in the subjects on limited water. Uniformly there was a marked reduction over the pre-period (control) test. In two instances, no urine above the basal flow was passed during the four-hour recovery period. This phenomenon was always correlated with clinical evidence of dehydration; viz., the third bar (Subject No. 6) in N 3000 L and the bar (Subject No. 7) in 30/0/70 1000 L. In both men the specific gravity of the urine was high and remained unchanged during the entire period of collection, in striking contrast to normally hydrated individuals in whom the water load induces a copious flow of very dilute urine.

Caloric Intake: For the subjects on unlimited water and limited water there is no correlation between caloric intake and percent of recovery. The highest recoveries were for men on N 3000 U. On the limited water regimens, regardless of caloric intake, the recoveries were of the order of 25%. For the unlimited water they were of the order of 50%.

STAT
STAT

TABLE III. 44

AVERAGE DAILY FAT INTAKE

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery	(Rec-Pre)
		gm/day	gm/day	gm/day	gm/day	gm/day
N 3000	U	143	129	135	191	48
	L	136	134	138	165	29
ST 0	U	124	0	0	178	54
	L	126	0	0	190	64
0/100/0	U	123	0	0	181	58
1000	L	159		0	162	3
0/100/0	U	144	0	0	194	50
2000	L	149	0	0	234	85
30/0/70	U	142	74	75	255	113
1000	L	161	75	76	280	119
30/0/70	U	172	151	151	235	63
2000	L	164	151	151	177	13
2/20/78	U	105	91	89	224	119
1000	L	148	91	90	240	92
2/20/78	U	168	174	125	224	56
2000	L	143	155	95	96	-47
15/52/33	U	177	38	38	212	35
1000	L	152	38	38	210	58
15/52/33	U	147	78	78	175	28
2000	L	116	76	73	125	9

Nutrient mixture: No striking correlation between nutrient mixture and percent of recovery was observed except in the case of N 3000 L. For this mixture, the recoveries tended to be relatively low. The probable reason for this result is that the high solute load in this diet is the most capable of unbalancing the homeostatic mechanisms for conserving body water. The same explanation may apply to the low recovery for the subject on 30/0/70 2000 U and that for the subject on 30/0/70 2000 L.

Comment: The water diuresis test has been proposed by a number of investigators as a functional test of adrenal cortical hypofunction. Under these conditions the subject is in negative sodium balance and water diuresis is impaired. The uncontrolled Addisonian patient fails to show significant diuresis. Now the Addisonian who is not under adequate treatment is suffering from a metabolic disturbance which leads to dehydration as a consequence of vomiting and diarrhea. May it not be that the failure to show diuresis in the water tolerance test is the result of simple dehydration rather than of adrenal cortical dysfunction?

In the present investigation we adapted the working hypothesis that the diuretic response to a standard oral water load was

TABLE III. 45

WEIGHT LOSS (Mean and Range) IN RELATION TO NUTRIENT MIXTURE, CALORIC INTAKE, AND WATER INTAKE

Nutrient Mixture	Days on Regimen	Average Weight Loss Unlimited Water	Limited Water	Remarks
		kg	kg	
N 3000	5-14	0.7	2.9	Subject 5 fatal dehydrated after 5 days.
		0-1.6	1.8-3.8	
ST 0	7-14	7.2	7.6	Fasting: 7 days (1), 9 days (4), 11 days (1), 14 days (1).
		5.7-7.1	5.6-9.8	
0/100/0 1000	12-14	5.7	6.5	
		5.3-6.1	5.7-7.2	
0/100/0 2000	12-14	4.5	5.2	
		4.1-4.5	5.2-5.3	
30/0/70 1000	7-14	5.5	6.4	Subject 7 given 1000 Cal extra carbohydrate days 8-14.
		---	---	
30/0/70 2000	14	4.6	4.8	
		---	---	
2/20/78 1000	14	5.3	6.7	
		---	---	
2/20/78 2000	9-14	3.9	5.5	Subject 12 taken off regimen because of intolerance to fat.
		---	---	
15/52/33 1000	9-14	4.2	5.4	
		4.2-4.3	4.6-6.3	
15/52/33 2000	6-14	3.6	3.3	Subject 3 and 8 taken off regimen on days 7 and 10 because of intolerance for diet limited water.
		3.3-3.8	2.0-4.5	

STAT
STAT

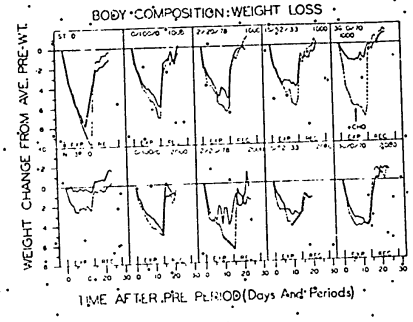

FIGURE III. 20. BODY COMPOSITION: WEIGHT LOSS

Continuous Line, Unlimited Water; Dashed Line, Limited Water; Double Line, No Data Because Subject Was Taken Off Regimen before End of 14-Day Interval.

dependent upon the degree of dehydration rather than hypofunction of the adrenal cortex. Although the latter factor cannot be conclusively ruled out, we are inclined to believe that our subjects experienced overactivity rather than underactivity of the adrenal cortex during subsistence on the experimental diets. The data on endocrine function supporting this point of view are discussed in detail later in the present report.

Supporting evidence of the simple dehydration hypothesis will be found in Table III. 49 from which two generalizations can be drawn. First, limitation of water led to a substantial reduction in the percentage recovery of a test dose during the second experimental week as compared both with the pre-period for the same subject and also with other subjects on unlimited water during the experimental period. Second, when a plot is made of the water balance in the second experimental week against the difference in percentage recovery of test dose between the pre-period and the second experimental week, there is a good correlation. The more nearly in positive water balance the subject remained, the less

TABLE III. 46

MEAN DAILY WEIGHT OF SUBJECTS DURING THE PRE-PERIOD (Kg)

Subject No.	Pre-Period I	II	III	IV	V
1	70.1	69.6	68.9	69.7	69.8
2	70.6	71.4	69.2	70.6	69.4
3	83.1	80.4	78.3	79.4	79.1
12	----	78.8	74.6	76.8	74.5
5	65.4	65.3	64.8	64.8	66.2
6	64.2	63.6	64.1	65.0	64.7
7	66.0	65.9	67.2	70.1	67.9
9	65.6	67.9	69.6	70.4	68.1

difference there was in diuretic response in the pre- and experimental period. To our knowledge this is first direct evidence that the water diuresis test may be used as a quantitive measure of the state of hydration. The usefulness of the test is enhanced by the fact that the rate-base of our subjects was independent of caloric intake, solute load from the diet, and ratio of protein/carbohydrate/fat in the nutrient mixture.

3. Body Fat

Control measurements of body fat are summarized in Table III. 50. All of the subjects had low values for this body constituent. They fell in the 20 percentile group of Brozek and Keys (1951). However, these data do not differ appreciably from those reported by the Army Medical Nutrition Laboratory (Best and Kuhl, 1953) and the Quartermaster Climatic Research Laboratory (Quinn et al., 1953). The ranges of values for body fat were rather wide, but in large part this variance was attributable to a general upward trend (? accumulation) of body fat with the passage of time (Table III. 51). The trends are significant: each man showed the upward tendency.

The experimental data are summarized in Tables III. 52 and 53; the first showing the changes in percent of body fat, the second changes in Kg of body fat. The means and ranges of each are indicated for the pre-period, experimental periods, and recovery periods. In general the loss of body fat was small. No clear correlation could be established between nutrient mixture and loss of body fat, but there was a tendency for more fat to be lost the lower the caloric intake.

TABLE III: 47

ANTIPYRINE SPACE IN RELATION TO EXPERIMENTAL NUTRIENT MIXTURE
(Mean and Range)

Nutrient Regimen	Unlimited Water Liters	Unlimited Water % Body Wt	Limited Water Liters	Limited Water % Body Wt
Control	37.8	54.2	----	----
data	33.6-47.3	46.5-69.0	----	----
N 3000	35.0	49.9	----	----
	33.4-36.6	49.8-50.0	----	----
ST 0	36.7	57.5	33.0	47.5
	32.3-39.4	50.3-61.7	25.8-33.2	42.8-51.5
0/100/0	28.2	43.0	29.6	47.0
1000	----	----	----	----
0/100/0	42.6	60.0	33.1	44.8
2000	----	----	----	----
15/52/33	40.0	61.2	36.6	55.8
1000	----	----	----	----
2/20/78	32.8	54.4	28.1	49.1
1000	----	----	----	----
30/0/70	29.0	41.4	27.6	41.0
1000	26.3-31.8	40.0-42.7	24.1-31.1	39.4-42.5

The validity of these measurements can, however, be seriously questioned in the light of the fact that chronic dehydration seemed to prejudice the results. It will be recalled that evidence was presented in Section II (Table II. 17) that dehydration of a subject in caloric balance and constant caloric intake was associated with an apparent increase in body fat. This finding led to a study of all our data from this point of view. The results are summarized in Table III. 54. According to this analysis, with but one exception (30/0/70 1000), there was a smaller loss of body fat in the case of subjects on limited water than in the case of subjects on unlimited water. In two cases (2/20/78 2000 and N 3000) there was an increase in body fat. These results suggest that changes in the water content of the body alter the skin in such a way as to invalidate the equations of Brozek and Keys (1951) in so far as applying them to dehydrated men is concerned. These regression equations were calculated from normal healthy subjects who presumably were in caloric and water balance. Because of this finding we hesitate to make calculations of changes in lean body mass in the case of our subjects on limited water. We further point out that the data reported by Quinn et al. (1953ab) may be erroneous because it was assumed that changes in skin-fold thickness in men on 800 ml/day of water accurately represented concurrent changes in body fat. If this method is to be used in nutritional surveys or clinical investigation, the method should be fully validated and standardized for a wide variety of abnormal conditions.

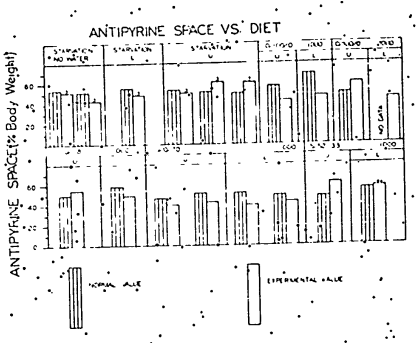

FIGURE III. 21. ANTIPYRINE SPACE VS. DIET

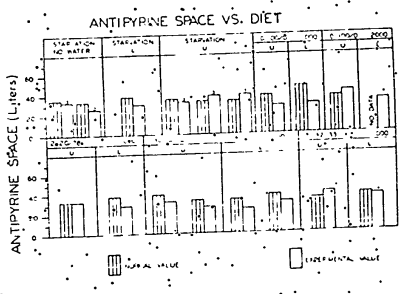

FIGURE III. 22. ANTIPYRINE SPACE VS. DIET

STAT
STAT

TABLE III. 48

BODY WATER DETERMINATIONS BY SIMULTANEOUS INTRAVENOUS INFUSION OF D_2O AND ANTIPYRINE

Date and Subject	Regimen	Body Water D_2O l	Body Water D_2O % Body Wt	Body Water Antipyrine l	Body Water Antipyrine % Body Wt
30 May 2	Recovery	38.7	56.6	37.9	55.4
23 May 3	0/100/0 2000 L	40.0	54.3	33.1	44.8
23 May 12	0/100/0 2000 U	47.9	68.4	42.0	60.0
5 June 5	N 3000 L	39.6	59.6	33.4	50.0
11 June 6	Recovery	38.6	59.8	37.5	58.0
23 May 7	Pre-Period	41.0	60.0	47.3	69.0
11 June 8	Recovery	37.7	56.3	38.2	57.0
17 May 9	No Water, No Food	39.0	60.5	33.2	51.5
31 May 9	Water, No Food	43.1	67.0	32.3	50.3
13 June 9	Normal	42.6	64.4	35.6	53.7
17 May 11	Water, No Food	39.2	63.4	38.3	61.7
31 May 11	No Water, No Food	35.5	58.9	25.8	42.8

CAPTION FOR FIGURES III. 23 and III. 24
WATER DIURESIS I and II

Percent of recovery of water load (20 ml/kg) in the four-hour period following oral ingestion of water in relation to experimental regimens. Water tests were given at end of pre-periods and end of experimental periods. Each bar represents the reaction of a single subject. Bars have been arranged in the same order, with respect to subjects, in the experimental periods as in the pre-periods. Black spaces represent percent of recovery accounted for by basal excretion.

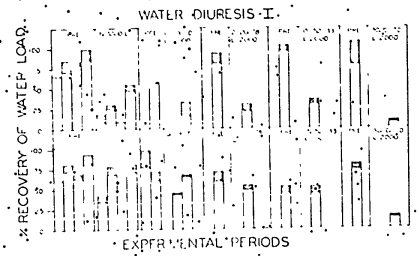

FIGURE III. 23

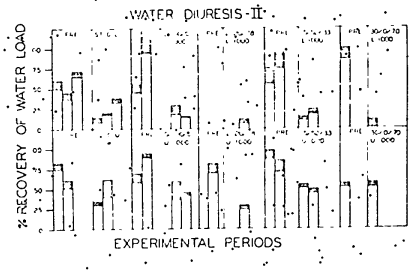

FIGURE III. 24

STAT
STAT

TABLE III. 49

RECOVERY OF WATER LOAD VS. WATER BALANCE

Condition and Subject	% Recovery (Corrected) Pre	Exp II	Pre-Exp II	Water Balance Pre 1/day	Exp II 1/day	Pre-Exp II 1/day
N 3000 L						
1	65	8	57	+1.02	-0.24	+1.26
3	71	25	46	-0.03	-0.31	+0.28
6	79	0	76	+0.60	-0.12	+0.72
8	85	47	38	+0.48	-0.60	+1.08
N 3000 U						
2	62	34	28	+0.46	-0.48	+0.94
12	72	68	4	+0.36	+0.22	+0.14
5	63	72	-9	+0.96	+0.57	+0.39
7	81	71	10	+0.72	+0.45	+0.27
0/100/0 2000 L						
3	56	16	40	+0.15	-0.13	+0.28
0/100/0 2000 U						
2	77	43	34	-0.08	+0.60	-0.68
12	65	65	0	+0.16	+0.56	-0.72
2/20/78 2000 L						
12	81	21	60	+0.16	-0.59	+0.75
2/20/78 2000 U						
3	59	48	11	-0.34	-0.03	-0.31
15/52/33 2000 L						
8	95	29	66	+0.38	-0.14	+0.52
15/52/33 2000 U						
4	43	46	-3	+0.73	+0.40	-1.13
30/0/70 2000 L						
1	78	6	72	+0.65	-0.32	+0.97
30/0/70 2000 U						
2	73	13	60	-0.41	-0.17	-0.24
ST 0 L						
2	50	8	42	0.00	-0.30	+0.30
3	37	18	19	-0.36	-0.22	-0.14
8	65	33	32	-0.45	-0.49	+0.94
ST 0 U						
12	75	25	50	+0.09	-0.48	+0.57
7	52	35	17	+0.43	-0.13	+0.56

TABLE III. 49 (Cont.)

Condition and Subject	% Recovery (Corrected) Pre	Exp II	Pre-Exp II	Water Balance Pre 1/day	Exp II 1/day	Pre-Exp II 1/day
0/100/0 1000 L						
5	45	18	27	+0.15	-0.20	+0.35
7	95	14	81	+0.88	-0.36	+1.24
0/100/0 1000 U						
6	58	37	21	+0.44	+0.05	+0.39
8	89	42	47	+0.47	-0.23	+0.70
2/20/78 1000 L						
6	65*	7	58	+2.13	+0.08	+2.05
2/20/78 1000 U						
5	70	24	46	-0.13	+0.07	-0.20
15/52/33 1000 L						
2	56	11	45	-0.23	-0.34	+0.11
5	75	18	57	+0.81	-0.34	+1.15
15/52/33 1000 U						
1	87	51	36	+0.87	+0.18	+0.69
4	71	44	27	+1.24	+0.16	+1.08
30/0/70 1000 L						
7	86	1	85	+0.58	-0.57	+1.15
30/0/70 1000 U						
8	52	52	0	+0.90	+0.01	+0.89

*Mean of subject's other pre-periods.

4. Lean Body Mass

The classical method of studying changes in lean body mass is to use calculations based upon empirical equations and alterations in nitrogen and mineral balance. The formulae are no more valid than the assumptions on which they are based. We have discussed some of these assumptions in Section II. Here we wish to present some of our data which support the critique of methodology by Rombunger et al, (1952).

The Nitrogen/Phosphorus Ratio. One of the basic contentions of the investigators who devise empirical equations for calculating changes in lean body mass is that the nitrogen/phosphorus

STAT
STAT

TABLE III. 50

MEANS AND RANGES OF BODY FAT* DURING PRE-PERIODS

Subject No.	Body Fat, % Body Wt Mean	Range	Body Fat, kg Mean	Range
1	3.8	3.6-4.0	2.5	2.0-2.8
2	6.0	5.0-7.0	4.2	3.6-4.9
3	4.9	3.9-5.8	3.8	3.0-4.7
4	---	---	---	---
5	7.5	6.7-8.6	4.9	4.4-5.7
6	5.5	4.9-6.1	3.5	3.1-3.9
7	5.9	5.0-6.8	4.0	3.3-4.6
8	4.7	4.1-5.1	3.2	2.8-3.6
12	5.6	3.6-6.8	4.2	2.6-5.1

*Skinfold Thickness Method.

TABLE III. 51

BODY COMPOSITION: CHANGE IN BODY FAT DURING SUCCEEDING PRE-PERIODS

Subject No.	Pre-Period II	III	IV	V
	A. % Body Fat			
1	3.8	3.6	3.9	4.0
2	5.0	5.6	6.5	7.0
3	4.0	3.9	5.8	5.8
5	6.7	6.9	7.8	8.6
6	4.9	5.1	6.1	5.8
7	5.0	5.5	6.2	6.8
8	4.1	4.8	5.1	4.8
12	3.6	6.0	6.2	6.8
Mean	4.6	5.2	6.0	6.2
	B. Kg Body Fat			
1	2.6	2.0	2.7	2.8
2	3.6	3.9	4.6	4.9
3	3.2	3.0	4.6	4.7
5	4.4	4.5	5.0	5.7
6	3.1	3.3	3.9	3.7
7	3.3	3.7	4.4	4.6
8	2.8	3.3	3.6	3.3
12	2.6	4.4	4.7	5.1
Mean	3.2	3.5	4.2	4.4

TABLE III. 52

BODY COMPOSITION: PERCENT BODY FAT* IN RELATION TO DIETARY REGIMEN (Means and Ranges)

Nutrient Mixture	Pre-Period	Experimental I	II	Recovery
N 3000	5.8	5.6	5.7	6.5
	3.9-8.6	3.9-8.2	4.9-8.2	5.0-9.4
Sr 0.	5.0	4.0	3.9	4.3
	3.6-7.5	2.5-6.2	2.7-5.0	3.2-5.2
0/100/0	5.1	5.9	5.2	5.4
1000	4.6-6.7	5.0-7.5	3.7-6.6	4.5-7.0
0/100/0	5.9	5.8	5.0	5.3
2000	4.6-7.0	3.6-7.3	3.3-5.8	3.6-6.8
2/25/78	6.0	5.7	5.4	5.9
1000	5.1-6.9	4.9-6.5	4.8-6.0	5.0-6.8
2/25/78	6.0	5.4	5.7	4.7
2000	5.8-6.2	4.9-5.8	4.4-7.0	3.9-5.5
15/52/33	6.1	5.6	5.1	5.8
1000	5.2-7.8	3.5-6.9	3.1-6.2	4.0-8.1
15/52/33	5.8	5.0	4.9	4.5
2000	4.6-6.8	4.3-5.6	4.5-5.3	---
30/0/70	4.6	4.6	3.3	4.2
1000	4.1-5.0	4.2-5.0	3.1-3.5	---
30/0/70	4.6	4.5	4.1	4.6
2000	3.6-5.6	3.2-5.8	2.9-5.3	3.5-5.7

*Skinfold Thickness Method.

ratio calculated from urinary and fecal data is a fixed constant and representative of the lean body mass. The lean body mass has the same N/P ratio as muscle; viz., 14.7. Changes in nitrogen when either anabolism or catabolism of lean body mass is taking place should be accompanied by concurrent alterations in phosphorus, while the N/P ratio is constant. Homburger et al. (1952) found that in normal as well as in debilitated subjects the nitrogen/phosphorus ratio was far from constant. This variability tended to invalidate the use of empirical equations based upon the assumption that the ratio was constant. Data collected during the present investigation likewise reveal a wide variability of the ratio. We have gathered all the N/P ratios into one table of frequency distribution (Table III. 55). The N/P ratios for the food consumed are shown in the left-hand column, those for the urinary and fecal output are shown in the right-hand column. For the "intake" 147 periods were available, for the output 165. N/P ratios for intake could not be calculated for starvation and the 0/100/0 regimens. Two significant facts are evident from a study of this table. (1) The intake-ratios are not distributed according to the normal curve. There is a

STAT
STAT

TABLE III. 53

BODY COMPOSITION: BODY FAT,* Kg, IN RELATION TO DIETARY REGIMEN
(Means and Ranges)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	4.0	3.6	4.0	4.4
	3.0-5.7	2.9-5.4	3.4-5.4	3.4-6.3
ST 0	3.4	2.6	2.3	2.9
	2.6-4.9	1.5-3.8	1.5-3.2	2.1-3.9
0/100/0	3.9	3.8	3.2	3.6
1000	3.1-4.4	3.0-4.7	2.2-4.2	2.8-4.7
0/100/0	4.4	4.1	3.4	3.8
2000	2.8-5.1	2.4-5.4	2.2-3.9	2.4-4.6
2/20/78	3.9	3.5	3.2	3.8
1000	3.3-4.5	3.0-4.0	2.8-3.6	3.1-4.4
2/20/78	4.6	4.0	4.2	3.6
2000	4.6-4.7	3.7-4.2	3.5-5.0	3.0-4.1
15/52/33	4.0	3.6	3.2	3.8
1000	2.7-5.0	2.4-4.6	2.0-3.8	2.7-5.3
15/52/33	4.0	3.2	3.2	3.0
2000	3.8-4.6	2.8-3.7	3.0-3.4	--
30/0/70	3.0	2.9	2.0	2.8
1000	2.8-3.3	2.7-3.1	1.8-2.1	2.8-2.9
30/0/70	3.0	3.0	2.7	3.2
2000	2.0-3.9	2.1-3.9	1.9-3.5	2.4-4.0

*Skinfold Thickness Method.

biphasic distribution with maxima below 10.0 and at 12.0-12.9. (2) The output-ratios are distributed more normally. There is a small secondary maximum at 20.0 or greater; these ratios ranged up to 33.8. The mode of the output-ratios is close to the theoretical 14.7. These facts suggest that the N/P ratio of the food played no role in the distribution of the output-ratios. More likely the output-ratio was a function of alterations, anabolic and catabolic, in body substance. The variability about the mode, however, is so wide that it would be futile to attempt to define what tissue or groups of tissues were represented by the mean ratio ± its standard deviation. Even in the pre-period wide variations in this ratio occurred between subjects and within the same subject, thus confirming the observations of Homburger et al. (Table III. 56).

When scrutinized in relation to the actual dietary regimen, the N/P ratios showed wide variations (Table III. 57). There was a tendency, albeit not too convincing, for the N/P ratio to be higher in the recovery periods than at any other time and for it to be lowest in the first week of experimental periods. It is evident

TABLE III. 54

INFLUENCE OF CHRONIC DEHYDRATION ON BODY FAT AS DETERMINED BY SKINFOLD THICKNESS METHOD

Nutrient Mixture	Mean Apparent Decrease of Body Fat* U %	L %
ST 0	43.2	26.4
1000 Cal/day		
0/100/0	23.5	13.6
2/20/78	10.6	15.2
15/52/33	21.2	20.8
30/0/70	25.0	46.5
2000 Cal/day		
0/100/0	24.0	16.2
2/20/78	19.6	-6.4
15/52/33	26.1	10.0
30/0/70	10.3	5.0
N 3000	6.5	-9.1

*Calculation Apparent Decrease in Body Fat = 100 x

$$\frac{\text{Body Fat (kg) in Pre-Period} - \text{Body Fat (kg) in Exp. II}}{\text{Body Fat (kg) in Pre-Period}}$$

TABLE III. 55

FREQUENCY DISTRIBUTIONS OF N/P RATIOS IN FOOD AND EXCRETA

N/P Ratio	Frequency Intake[1]	Output[2]
Less than 10.0	30	5
10.0 - 10.9	10	4
11.0 - 11.9	18	11
12.0 - 12.9	31	16
13.0 - 13.9	20	23
14.0 - 14.9	14	31
15.0 - 15.9	13	23
16.0 - 16.9	3	14
17.0 - 17.9	1	10
18.0 - 18.9	0	6
19.0 - 19.9	0	5
20.0 and greater	7	17
Total	147	165

[1]Calculated from total nitrogen and total P consumed.

[2]Calculated from total (urine + feces) output of Ca, P, and N as described in Section II.

TABLE III. 56

PRE-PERIOD DATA FOR NITROGEN/PHOSPHORUS RATIO

Subject No.	Nitrogen/Phosphorus Ratio		
	Mean	σ	C.V.
1	16.1	2.7	14.9
2	14.2	1.0	7.0
3	14.3	1.9	13.3
4	15.1	---	---
5	14.7	1.6	10.9
6	13.5	1.9	14.1
7	16.6	3.3	19.8
8	14.5	1.6	11.0
12	14.8	0.7	4.7

TABLE III. 57

NITROGEN/PHOSPHORUS RATIOS IN RELATION TO EXPERIMENTAL REGIMEN

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	15.4	13.7	17.5	18.3
	13.1-18.7	8.3-15.4	11.4-28.4	11.1-33.8
ST 0	13.9	10.9	14.0	19.5
	12.2-16.3	5.8-15.5	11.6-15.5	12.8-24.3
0/100/0	14.2	13.4	12.9	17.4
1000	12.1-17.2	12.2-14.4	11.7-13.9	14.6-23.9
0/100/0	14.7	12.3	17.4	14.6
2000	13.8-15.5	11.2-14.4	13.2-27.2	12.9-16.5
2/20/78	14.7	13.1	17.4	19.1
1000	12.6-16.8	12.0-14.2	16.0-18.9	13.5-24.6
2/20/78	13.6	12.8	12.6	15.9
2000	12.0-15.1	12.1-13.6	12.2-13.0	15.3-18.5
15/52/33	15.4	13.4	14.4	15.8
1000	13.0-19.7	11.8-15.6	12.6-16.9	14.4-19.3
15/52/33	18.1	11.5	11.1	13.7
2000	15.1-22.9	10.5-12.9	7.3-14.4	10.9-17.1
30/0/70	14.7	13.8	15.6	19.4
1000	14.1-15.3	13.8-13.9	14.8-16.4	17.7-21.1
30/0/70	19.2	16.7	17.2	17.9
2000	15.8-22.7	16.3-17.1	17.0-17.4	15.3-20.5

from our data that even when the caloric intake is adequate and the dietary N/P is fixed, the subjects' N/P ratio is not constant, nor does it equal the theoretical 14.7.

The Theoretical Nitrogen Balance. This balance was calculated from data on calcium and phosphorus balances as described in Section II. The theoretical balance was the actual nitrogen balance in 162 seven-day periods (Table III. 58). It is at once evident that these two balances are correlated; i.e., tend to vary concurrently. The fit of the data along the theoretical line is not close and the variability is so wide that one would hardly be justified in estimating the actual nitrogen balance from the theoretical balance or in using such data in studying changes in lean body mass. Our findings are in entire agreement with those of Homburger et al. (1952).

The criticism may be raised that agreement between theory and experiment can only be expected if the subjects are in equilibrium. Certainly in many periods our subjects were not in equilibrium. However, these situations are those in which it would be most desirable to know what actual changes are occurring in the body composition. The most meaningful information - especially from the point of view of stress physiology - is the dynamics of the unsteady state rather than the dynamics of the steady state. Since our subjects were in metabolic equilibrium in a number of the periods of this investigation, we hope that more detailed analysis of these data will yield further information on the validity of such theoretical calculations as we have discussed in the preceding paragraphs.

In summary, then, we would emphasize that data derived from such equations must be interpreted with caution and in the light of familiarity with the assumptions involved. No matter how attractive the particular investigator's conclusions may be, they are no more valid than the several assumptions involved. And there is a growing body of metabolic data demonstrating that these assumptions may not be as valid as originally claimed.

D. ORGAN AND SYSTEM FUNCTIONS

1. Liver Function

The battery of liver function tests conducted in this investigation was comprised of (1) serum cholin esterase, (2) two-hour urobilinogen excretion, (3) serum cephalin flocculation reaction, and (4) free cholesterol, esterified cholesterol, and total cholesterol in the serum. These tests were conducted at regular intervals throughout each phase of the investigation so that light might be shed on the alteration in functioning of the liver.

STAT
STAT

TABLE III. 58

CORRELATION BETWEEN THEORETICAL AND ACTUAL NITROGEN BALANCE IN 162 SEVEN-DAY PERIODS
Actual Nitrogen Balance (gm/day)

Theoretical Nitrogen Balance (gm/day)	-13.0-14.9	-11.0-12.9	-9.0-10.9	-7.0- 8.9	-5.0- 6.9	-3.0- 4.9	-1.0- 2.9	-0.9- 0.9	+1.0+ 2.9	+3.0+ 4.9	+5.0+ 6.9	+7.0+ 8.9	+9.0+10.9	+11.0+12.9	+13.0+14.9
13.0-14.9								2							0*
11.0-12.9										1				0*	1
9.0-10.9											2	2	1*		
7.0- 8.9									1	2	3	1*	1		
5.0- 6.9									1	5	3*				
3.0- 4.9									2	3*	4	1	1		
1.0- 2.9							2	3	4*	4	3	1			
- 0.9- 0.9						1	2	3	4*	7	5	4			
- 1.0- 2.9							2	1*	5	6	4	1			
- 3.0- 4.9						3	2*	2	6	4					
- 5.0- 6.9					1		8*	3	2	2			1		
- 7.0- 8.9				1		2*	6				1				
- 9.0-10.9			1		4*	2	1	1							
-11.0-12.9				0*	3		1								
-13.0-14.9		0*	1	1											
-15.0-16.9					1										
-17.0-18.9															
-19.0-20.9			1		1.										
-21.0-22.9	1														
-23.0-24.9															

*Starred numbers fall along line of correlation expected from theory.

Serum Cholinesterase. The mean pre-period serum cholinesterase for each subject, together with the standard deviation and coefficient of variation, is shown in Table III. 59. Each of these data is within the accepted range of normal. These values were used to calculate the data summarized in Figure III. 25. The individual values for each subject are summarized in Appendix II.

TABLE III. 59

LIVER FUNCTION: PRE-PERIOD DATA FOR TWO-HOUR UROBILINOGEN AND SERUM CHOLINESTERASE

Subject No.	Urobilinogen (E.U./2 hr) M.	σ	C.V.	Serum Cholinesterase (Δpi/hr) M.	σ	C.V.
1	0.86	0.23	26.8	0.74	0.06	8.1
2	0.94	0.25	26.6	0.96	0.05	5.2
3	1.16	0.32	27.6	0.85	0.10	11.8
12	1.19	0.26	21.8	0.74	0.03	10.8
4	0.73	----	----	1.08	----	----
5	0.86	0.20	23.2	0.62	0.04	6.5
6	0.81	0.20	24.7	0.89	0.02	2.2
7	1.02	0.23	22.5	0.72	0.06	8.3
8	0.84	0.21	25.0	1.38	0.07	5.1

According to the information in Figure III. 25, there were marked alterations in serum cholinesterase. In general the values reached their minima early in the recovery period and then returned to control values by the time the succeeding experimental period began. There is no evidence that the alterations were appreciably different when the two levels of water intake are compared, with the possible exception of 15/52/33 L 2000. In this instance, the two subjects on limited water became ill and had to be removed from the regimen. This point will be discussed below. The difference between the two water regimens in the case of 2/20/78 2000 may be an individual difference; only two subjects were tested.

Caloric intake: The maximum alteration in serum cholinesterase occurred following starvation; the least, following positive control. Every 1000-Calorie regimen was associated with a marked drop which tended to be less as the intake of protein increased. The magnitude of the diminutions, however, was not much different from starvation. At the 2000-Calorie level the magnitude of the decreases was less than at 1000 Cal, the 0/100/0 and 30/0/70 regimens causing no significant change. Each regimen at 1000 Cal and fasting was associated with a rise above control levels during the early part of the experimental period. A similar trend was found in the 2000-Calorie regimens.

Nutrient mixture: The different dietary combinations did not in themselves seem to cause the alterations in serum cholinesterase,

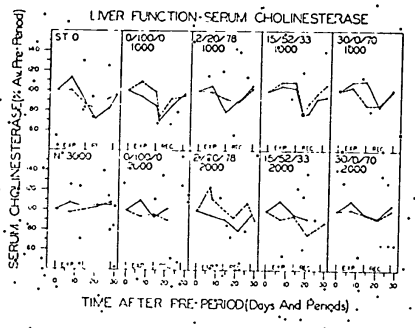

FIGURE III. 25
LIVER FUNCTION: SERUM CHOLINESTERASE :
Continuous Line; Unlimited Water; Dashed Line, Limited Water.

with the exception of 2/20/78 2000 U and L and 15/52/33 L 2000. These three regimens were associated with clinical symptoms which were probably due to the ration components.

Comment: The early rises in serum cholinesterase are not understood. It may be that they represent the accelerated catabolism of body tissues which occurs during a caloric deficit. Nitrogen mustard, which causes breakdown of tissue, causes an increase in serum cholinesterase, presumably released from the catabolized cells (Voshaus and Kark, 1953).

The diminution in serum cholinesterase is most probably a manifestation of liver dysfunction. Since this test is a delicate one, it is presumable that the liver damage is not marked and that it is rapidly repaired during the recovery period. Caloric deficiency seems to be the most generally provocative factor. In so far as the claim that the serum cholinesterase might serve as index of nutritional status is concerned (Nutrition Reviews, 1952), our data indicate that the level may well be correlated with caloric nutriture.

Urobilinogen. Control values for each subject have been summarized in Table III. 59. They all fell within the clinically normal range. The variations observed in tests conducted while the subjects were subsisting on the several nutrient mixtures have been tabulated in Table III. 60. Only one consistent trend was observed in relation to nutrient mixture. When the protein ratio in the nutrient mixture was low, the urobilinogen during the experimental periods tended to be lower than in the pre- or recovery periods. On the other hand, when the protein ratio was high, the reverse was true. Several abnormal values, however,

TABLE III. 60

LIVER FUNCTION: TWO-HOUR UROBILINOGEN TEST
(Mean and Range)

Nutrient Mixture	Pre-Period E.U./2 hr	Experimental I E.U./2 hr	Experimental II E.U./2 hr	Recovery E.U./2 hr
N 3000	0.91	1.30	1.01	0.99
	0.49-1.24	0.78-1.60	0.40-1.51	0.66-1.62
ST 0	0.93	0.68	0.41	1.08
	0.43-1.73	0.43-1.19	0.20-0.64	0.54-1.77
0/100/0 1000	1.04	0.85	0.97	1.32
	0.81-1.26	0.39-1.12	0.87-1.08	0.44-1.92
0/100/0 2000	1.10	0.87	0.69	1.19
	0.99-1.21	0.67-1.08	0.49-0.98	0.89-1.49
2/20/78 1000	0.88	0.50	0.57	0.48
	0.82-0.95	0.35-0.64	0.52-0.62	0.46-0.50
2/20/78 2000	1.16	1.06	0.98	1.69
	1.14-1.17	0.42-1.69	0.51-1.25	0.97-2.38
15/52/33 1000	0.98	0.94	1.34	0.96
	0.83-1.23	0.68-1.09	0.70-2.28	0.34-1.89
15/52/33 2000	0.81	0.79	0.84	1.36
	0.73-1.26	0.48-1.23	0.27-1.19	0.48-1.97
30/0/70 1000	0.86	1.20	1.62	0.66
	----	0.84-1.55	1.28-1.95	0.65-0.66
30/0/70 2000	0.85	1.07	1.06	0.88
	0.70-1.00	0.93-1.21	0.95-1.17	0.62-1.14

were recorded: 2.38 E.U./2 hr during recovery from 2/20/78 2000 and 2.28 during the second experimental week of 15/52/33 1000. High normal values were recorded during recovery from 0/100/0 1000, 15/52/33 1000, 15/52/33.2000: 1.92, 1.82, and 1.97 E.U./2 hr, respectively; and during the second experimental week on 30/0/70 1000: 1.95 E.U./2 hr. Most of these high normal or abnormal values were associated with the development of clinical symptoms and signs presaging functional breakdown.

Cephalin Flocculation Reaction. The serum flocculation reactions used in any battery of liver function tests must be

interpreted cautiously. One indication of this situation is that the upper limit of normal for the cephalin flocculation test is +1. Furthermore, every trial should be accompanied by a blank, a normal control, and serum known to yield a +4 reaction. The latter control was not feasible in these studies, but the blank and normal controls were regularly included. Our observations on the relation of this reaction to the several dietary regimens have been summarized in Table III. 61.

TABLE III. 61

LIVER FUNCTION: 24 HR/48 HR CEPHALIN FLOCCULATION REACTION*

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	U	3 x 0	3 x 0	3 x 0	0/0, 0/0, 0/+
	L	3 x 0	3 x 0	3 x 0	0/0, 0/0, 0/+
ST 0	U	N.D.**	N.D.	0/0, 2+/4+	0/0, 0/tr
	L	N.D.	N.D.	0/+, 2+/4+	2 x 0
0/100/0	U	2 x 0	2 x 0	0/c, 0/+	2 x 0
1000	L	2 x 0	2 x 0	2 x 0	2 x 0
0/100/0	U	2 x 0	0/tr, +/+	0/str, +/+	0/2+, 0/str
2000	L	2 x 0	2 x 0	2 x 0	0/2+, 0/2+
2/20/78	U	0/0	0/0	0/0	0/0
1000	L	0/0	0/0	0/0	0/0
2/20/78	U	0/0	0/0	0/0	0/0
2000	L	0/0	0/2+	3+/4+	0/0
15/52/33	U	2 x 0	2 x 0	2 x 0	2 x 0
1000	L	2 x 0	2 x 0	2 x 0	2 x 0
15/52/33	U	0/0	0/0	0/0	N.D.
2000	L	0/0	0/2+	0/0	0/0
30/0/70	U	0/tr	0/2+	0/0	0/0
1000	L	0/0	0/0	0/0	0/0
30/0/70	U	0/c	0/0	0/0	0/0
2000	L	0/0	0/2+	0/+	0/0

*All reactions conducted with controls; controls were uniformly negative.
**N.D. = no data.

Several significant observations stand out on analysis of Table III. 61. (1) In the pre-period, there was never a reaction greater than trace (tr); 27 of 28 tests were negative. (2) Significantly positive reactions (greater than +1) were twice as common on the limited water regimen as on unlimited water regimen. (3) Significantly positive reactions were not related to caloric intake. (4) The nutrient mixtures which were associated with reactions of 2 or greater were starvation, 0/100/0 2000 (in the recovery period), 2/20/78 2000, 15/52/33 2000, 30/0/70 1000, and 30/0/70 2000. With the exception of the reactions after 0/100/0 2000, the others were associated with the development of clinical

symptoms and signs, the most serious of which always occurred in subjects on limited water.

Further analysis of our data indicated that the majority of the significantly positive cephalin flocculation reactions developed in sera obtained from three of the eight subjects (Table III. 62). Those three subjects had seven of the nine reactions greater than +2. There was no evidence that these men had any active or contributory liver disease (Subject 12 had an inactive calcified cyst of liver, presumably due to meningococcus; see Appendix IV). During the pre-periods they never manifested abnormal cephalin flocculation reactions. Two of these men were among those developing severe clinical deterioration. Perhaps these three individuals were more sensitive to the stresses of the abnormal dietary regimens than the other subjects. If the cephalin flocculation can be so interpreted, our present clinical experience is corroborative. On the other hand, it is well known that individuals vary in their manner of reaction to disease. One may show a predisposition to abnormal functioning of one organ while another reacts differently. Each has his locus minoris resistentiae. These subjects may have been alike in that locus was the liver and it was here that stress most easily produced a dysfunction.

Serum Cholesterol. In this investigation the total cholesterol, cholesterol esters, and free cholesterol were measured. The mean pre-period data for these three quantities for each subject have been summarized in Table III. 63. These values are entirely normal for the age group represented by our subjects. The changes occurring during and following subsistence on the several experimental regimens are illustrated for total cholesterol (Figure III. 26) and cholesterol esters (Figure III. 27). Since, in general, the cholesterol esters paralleled the total cholesterol, we can confine our attention to the alterations observed in the latter. Analysis of variance of these data has been performed by Dr. Leon J. Harter, Aeronautical Research Laboratory, Directorate of Research, Wright Air Development Center, Wright-Patterson Air Force Base. We summarize his findings in Table III. 64.

According to the analysis in Table III. 64A the caloric intake, the distribution of calories, and the interaction of these factors had significant effects on total serum cholesterol. Close inspection of the data plotted according to time revealed that in January and February, pre-period values were relatively low, they rose to maxima in March and April, and then fell again in May and June. This trend may have prejudiced the analysis since all the subjects showed the phenomenon to a greater or lesser extent. This cycle was removed by a technic described in Dr. Harter's detailed report (see Appendix II). A second analysis (Table III. 64B) now demonstrated that the action of caloric intake was no longer significant. The influence of the distribution of calories was even more marked and interindividual variability became significant at the 1% level. To

TABLE III. 62

LIVER FUNCTION: 24 HR/48 HR CEPHALIN FLOCCULATION REACTIONS* IN THREE REPEATEDLY POSITIVE REACTORS

Nutrient Mixture	Water	Pre-Period #1	Pre-Period #6	Pre-Period #12	Experimental Period I #1	Experimental Period I #3	Experimental Period I #12	Experimental Period II #1	Experimental Period II #8	Experimental Period II #12	Recovery #1	Recovery #8	Recovery #12
H 3000	U	--	--	0/0	--	--	0/0	--	--	0/+	--	--	0/+
	L	N.D.**	0/0	--	N.D.	0/0	--	N.D.	0/0	--	N.D.	0/+	--
ST 0	U	N.D.	--	--	N.D.	--	--	2+/4+	--	--	--	--	0/tr
	L	--	N.D.	N.D.	--	N.D.	N.D.	--	N.D.	2+/4+	--	N.D.	0/0
0/100/0	U	--	0/0	--	--	0/0	--	--	0/+	--	--	0/0	--
1000	L	--	--	--	--	--	--	--	--	--	--	--	--
0/100/0	U	--	--	0/0	--	--	+/+	--	--	+/+	--	--	0/str
2000	L	0/0	--	--	0/0	--	--	0/0	--	--	0/2+	--	--
2720/78	U	--	--	--	--	--	--	--	--	--	--	--	--
2000	L	--	--	0/0	--	--	0/2+	--	--	3+/4+	--	--	0/0
15/52/33	U	0/0	--	--	0/0	--	--	0/0	--	--	0/0	--	--
1000	L	--	--	--	--	--	--	--	--	--	--	--	--
15/52/33	U	--	--	--	--	--	--	--	--	--	--	--	--
2000	L	--	--	--	0/2+	--	--	0/0	--	--	0/0	--	--
30/0/70	U	--	0/tr	--	--	0/2+	--	--	0/0	--	--	0/0	--
1000	L	--	--	--	--	--	--	--	--	--	--	--	--
30/0/70	U	--	--	--	--	--	--	--	--	--	--	--	--
2000	L	0/0	--	--	0/2+	--	--	0/+	--	--	0/0	--	--

*All reactions conducted with controls; controls uniformly negative.

**N.D. = no data.

TABLE III. 63

PRE-PERIOD DATA FOR SERUM CHOLESTEROL
(Total, Esters, and Free, mg/100ml)

Subject No.	Total Cholesterol M	Total Cholesterol σ	Total Cholesterol C.V.	Cholesterol Esters M	Cholesterol Esters σ	Cholesterol Esters C.V.	Free Cholesterol M	Free Cholesterol σ	Free Cholesterol C.V.
1	209	46	22	169	53	31	42	27	63
2	221	61	28	213	55	26	24	20	83
3	149	26	17	132	32	24	15	17	89
4	278	--	--	187	--	--	91	--	--
5	197	11	6	174	41	23	24	20	83
6	171	18	10	151	30	20	20	15	75
7	260	25	10	218	36	16	41	18	44
8	240	48	20	205	57	28	35	17	48
12	138	21	15	126	25	20	13	11	85

identify the dietary factor causing these significant alterations in cholesterol a pair comparison was made with the "t" test. (Table III. 64C). The regimens 0/100/0 (A) and 2/20/78 (C) were not significantly different. The regimens 30/0/70 (B) and 15/52/33 (D) were both significantly different from A and C, and B was significantly different from D. The common factor in these significant changes was meat bar and this ration component was, by this study, implicated as the cause of the markedly increased serum cholesterol (Figure III. 26). That this food augments total cholesterol was shown by the fact that maximum levels of 337, 383, 399 and 430 mg/100 ml were measured in the four subjects subsisting on the regimen 30/0/70. These reactions bespeak simple dietary influences rather than alterations in liver function or thyroid function (Bodansky and Bodansky, 1952).

Free cholesterol: In addition to the periodicity of total cholesterol and cholesterol esters mentioned above, a curious variation was noted in level of serum free cholesterol. In successive pre-periods there was a tenfold diminution of this fraction (Table III. 65). Four of the subjects volunteered for a follow-up study of biochemical tests. They returned for venipunctures after only nine days of unrestricted eating and activity. An eightfold increase in free cholesterol had occurred. The only reasonable conclusion to be drawn is that some aspect of the investigative regimen had produced a rapidly reversible depression of free cholesterol. What this progressive alteration signifies, we are at a loss to say. Liver damage is not implicated, for such dysfunction would have caused an increase rather than a decrease in the free cholesterol (Bodansky and Bodansky, 1952).

Cholesterol esters and free cholesterol have been calculated as percentages of total cholesterol. Normal values were obtained

STAT

in the pre-periods (Table III. 66). No significant variations were observed in either percentage during experimental or recovery periods (Tables III. 67 and 68).

Urinalysis. The only qualitative reaction which yielded positive reactions was Ehrlich's urobilinogen test (Table III. 69). An occasional +2 reaction was observed but in general there was no significant variation with nutrient combination or correlation with the quantitative urobilinogen test. The test of Gmelin for bile was uniformly negative.

Clinical Observations. Detailed consideration of the correlation between biochemical and physiological measurements will be deferred until a later section. Here we merely summarize findings relevant to the liver and gall bladder. At no time was any icterus detected either clinically or biochemically. None of the subjects developed liver palms, gynecomastia, or enlarged (palpable) livers. Subject 3 exhibited some spider hemangiomata on his chest during recovery from 0/100/0 2000 L. Whether this capillary reaction can be attributed to an underlying liver dysfunction can not be conclusively established. At this time the cephalin flocculation reaction was +2 but the serum cholinesterase and urobilinogen were normal for the subject (Figure III. 45). Subject 12 had an attack which strongly suggested biliary dyskinesia during subsistence on 2/20/78 2000 L. A tender mass was palpable in the right upper quadrant, which may have been the gall bladder. The details of this episode are discussed below.

2. Kidney.

The function of the kidney is, of course, important at all times. Circumstances which impair its normal functioning might become disastrous in survival situations, and a very close study of it has been made in the present experiments.

Those measurements which will be discussed in this section relate to the physical properties of urine (urine volume, urine specific gravity and urine total solids); to the specific functioning of the kidney in relation to its ability to deal with osmotic load and the accumulation of nitrogenous endproducts of metabolism; and clinical observations which bear upon the integrity of the kidney (quantitative measurements of formed elements, qualitative analysis, and clinical examination of the subjects).

CAPTION FOR FIGURES III. 26 and III. 27

LIVER FUNCTION: TOTAL SERUM CHOLESTEROL AND SERUM CHOLESTEROL ESTERS.

Dashed Line, Limited Water; Continuous Line, Unlimited Water.

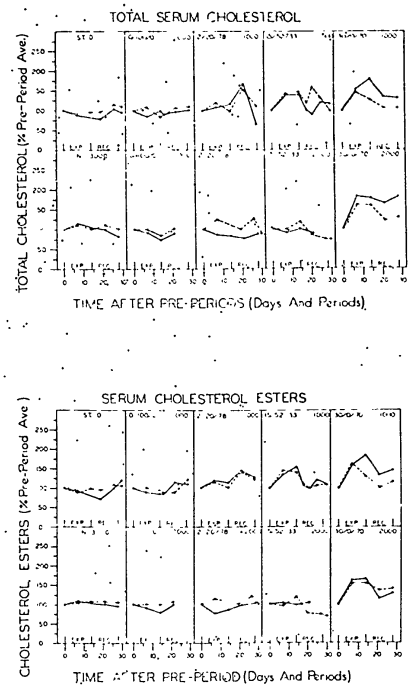

FIGURE III. 27

STAT

TABLE III. 64

ANALYSIS OF VARIANCE: TOTAL SERUM CHOLESTEROL

A. Before "Cyclical" Variation Removed.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Caloric Intake (C)	3	7662	2554	6.32**
Diet (D)	3	27262	9083	22.50**
Interaction (C x D)	3	4430	1477	3.66**
Individuals on same diet	30	12116	404	
Difference between weeks	40	12002	300	
Total	79	63474		

B. After "Cyclical" Variation Removed.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Caloric Intake (C)	3	1690	563	1.72
Diets (D)	3	24238	8079	24.71**
Interaction (C x D)	3	855	285	0.87
Individuals on same diet	30	9814	327	2.27**
Difference between weeks	40	5749	144	
Total	79	42348		

C. Paired Comparison of Diets by "t" Test.

Comparison	Observed Difference	S.E.	"t"
B-D	43.9	7.83	5.61**
B-A	62.1	7.83	7.93**
B-C	65.6	9.04	7.25**
D-A	18.2	6.39	2.85**
D-C	21.7	7.83	2.77**
A-C	3.5	7.83	0.45

**F or t value significant at 1% level.

TABLE III. 65

FREE CHOLESTEROL IN CONSECUTIVE PRE-PERIODS
mg/100ml.

Subject No.	Pre-Period I	I*	II	III	IV	V	Nine Days After Ending Experiment
1	55	69	47	30	30	0	45
2	39	59	0	21	23	4	70
3	38	44	19	15	0	0	37
4	82	100	--	--	--	--	--
5	44	29	54	8	8	0	--
6	42	34	26	8	7	4	--
7	66	49	62	23	30	16	--
8	48	43	62	15	29	16	--
12	--	34	29	15	8	0	19
Mean	52	53	37	17	17	5	43

*First pre-period two weeks in duration; individual weeks shown.

TABLE III. 66

PRE-PERIOD DATA FOR CHOLESTEROL ESTERS AND FREE CHOLESTEROL AS PERCENTAGE OF TOTAL CHOLESTEROL

Subject No.	Cholesterol Ester Mean	Cholesterol Ester Range	Free Cholesterol Mean	Free Cholesterol Range
1	79	58-100	21	0-42
2	88	72-100	12	0-28
3	86	69-100	14	0-31
4	66	61-72	34	28-39
5	87	74-100	13	0-26
6	87	74-98	13	2-26
7	83	73-94	17	6-27
8	84	75-95	16	5-25
12	87	75-100	13	0-25

STAT
STAT

TABLE III. 67

CHOLESTEROL ESTERS AS PERCENTAGE OF TOTAL CHOLESTEROL
(Mean and Range)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	87	83	88	85
	58-100	73-100	73-100	79-100
ST 0	79	86	80	82
	73-100	75-100	61-96	73-91
0/100/0	85	86	84	77
1000	77-89	75-92	73-94	48-96
0/100/0	99	90	97	94
2000	98-100	86-100	96-100	89-100
2/20/78	96	90	91	78
1000	------	85-96	------	76-81
2/20/78	97	81	94	93
2000	94-100	78-84	------	87-100
15/52/33	93	88	88	84
1000	87-96	77-95	82-93	71-92
15/52/33	79	84	77	81
2000	61-94	71-100	73-87	78-86
30/0/70	77	91	86	82
1000	------	90-92	86-87	80-85
30/0/70	91	81	84	94
2000	89-93	77-86	79-90	91-97

Urine Volume, Specific Gravity and Total Solids. Pre-Period data for urinary volume and specific gravity are shown in Table III. 70. The means for both were entirely reasonable, considering the high solute load imposed by the 5-in-1 ration. The extreme high values for subjects 1 and 7 were the result of their avidity for frequent cups of coffee.

During experimental periods the urine volumes fluctuated widely as a result of wide variations in the nutrient mixtures and in the water allowance (Tables III. 71A and III. 71B). With unlimited water, the least volumes were obtained with those mixtures that imposed the least solute load (0/100/0 1000 and 2/20/78 1000). Limitation of water led to a small urine output. Again, 0/100/0 and 2/20/78 gave the least volumes. The implications of these findings are discussed in the section on water balance.

Urinary specific gravity showed some interesting changes in the experimental periods (Tables III. 72A and III. 72B). When water was unrestricted, the highest mean specific gravity was 1.024; with restricted water, the highest mean was 1.033. Therefore, restriction of water made the kidneys approach their maximum concentrating capacity.

TABLE III. 68

FREE CHOLESTEROL AS PERCENTAGE OF TOTAL CHOLESTEROL
(Mean and Range)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	13	17	12	15
	0-42	0-27	0-27	0-21
ST 0	21	14	20	18
	0-27	0-25	4-32	9-27
0/100/0	15	14	16	23
1000	11-23	8-25	6-27	4-54
0/100/0	1	10	3	6
2000	0-2	0-44	0-4	0-11
2/20/78	4	10	9	22
1000	---	4-15	---	19-24
2/20/78	3	19	6	7
2000	0-6	16-22	---	0-13
15/52/33	7	12	12	16
1000	4-13	5-23	7-18	8-29
15/52/33	21	16	23	19
2000	6-39	0-29	13-27	14-22
30/0/70	23	9	14	18
1000	---	8-10	13-14	15-20
30/0/70	9	19	16	6
2000	7-11	14-23	10-21	3-9

A calculation of total urinary solids was made with Haser's equation (Haser and Vogel, 1954) and the results are graphed in Figure III. 28. It will be seen that the maximal total solids were to be found in the regimens when nitrogen intake and inorganic intake were highest. Limitation of water had little effect upon the total solids. Again, 0/100/0 and 2/20/78 caused the least total solids to be excreted.

Creatinine Clearance; Serum and Urinary Creatinine. As a measure of renal function (specifically, glomerular filtration rate) creatinine clearance has become popular. Its meaning and limitations have been discussed by Smith (1951) and Rapoport et al. (1949). In the present study it was measured routinely during all phases for all subjects. Pre-period data are presented in Table III. 73, and for all periods are summarized graphically in Figure III. 29.

During pre-periods, the serum creatinine for all subjects showed but little variation from a mean of 1.1 mg/100 ml blood, either between subjects or in the same subject from time to time. Creatinine clearance expressed as ml/min, or in the more conventional units ml/min/1.73 square meter, fell within accepted limits for normality.

STAT
STAT

TABLE III. 69

URINALYSIS: UROBILINOGEN (EHRLICH'S TEST)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	(29)*	(24)	(24)	(20)
	0(4) tr(19)	0(1) tr(11)	0(11) tr(8)	tr(15)
	+(5) 2+(1)	+(11) 2+(1)	+(5)	+(5)
ST 0	(36)	(24)	(10)	(23)
	0(1) tr(26)	tr(13)	tr(7)	0(2) tr(14)
	+(9)	+(9) 2+(2)	+(3)	+(7)
0/100/0	+(12)	(12)	(10)	(12)
1000	0(1) tr(4)	tr(10)	tr(6)	tr(9)
	+(7)	+(1) 2+(1)	+(3) 2+(1)	+(3)
0/100/0	(12)	(12)	(12)	(12)
2000	0(7) tr(3)	0(2) tr(3)	0(2) tr(7)	9(1) tr(9)
	+(2)	+(6) 2+(1)	+(3)	+(2)
2/20/78	(6)	(6)	(5)	(6)
1000	0(1) tr(3)	tr(4)	0(1) tr(3)	tr(4)
	+(2)	+(2)	+(1)	+(2)
2/20/78	(6)	(6)	(4)	(6)
2000	0(1) tr(3)	tr(2)	tr(4)	0(1) tr(3)
	+(2)	+(1) 2+(3)		2+(2)
15/52/33	(12)	(12)	(8)	(12)
1000	0(3) tr(7)	tr(5)	tr(4)	tr(9)
	+(2)	+(7)	+(3) 2+(1)	+(2) 2+(1)
15/52/33	(18)	(11)	(10)	(8)
2000	0(3) tr(6)	tr(6)	0(2) tr(4)	0(2) tr(5)
	+(8) 2+(1)	+(5)	+(4)	+(1)
30/0/70	(6)	(6)	(3)	(6)
1000	0(1) tr(3)		tr(1)	0(1) tr(1)
	+(2)	+(5) 2+(1)	+(1) 2+(1)	+(4)
30/0/70	(5)	(6)	(6)	(5)
2000	0(2) tr(2)	tr(2)	0(1) tr(2)	tr(5)
	2+(1)	+(4)	+(3)	

*Numbers in parentheses indicate number of specimens examined or number showing given degree of reaction.

In Figure III. 29 the creatinine clearances for the several experimental regimens are presented. In every case, the pre-period average for the individual subject was taken as 100%, and all other values were then referred to this figure as standard. Clearly, the glomerular filtration rate (G.F.R.) (as measured by creatinine clearance) tended to diminish under all experimental regimens. Disregarding the erratic fluctuations in the first week of 30/0/70 2000, the change during regimens with unlimited water was smallest and approximately the same in N 3000, 2/20/78 2000, 15/52/33 2000 and 30/0/70 2000 and 1000. In regimens on limited water, the change was smallest and approximately the same in N 3000 and 15/52/33 2000.

TABLE III. 70

PRE-PERIOD DATA FOR URINARY VOLUME AND SPECIFIC GRAVITY

Subject No.	Urine Volume Mean	Urine Volume Range	Urine Specific Gravity Mean	Urine Specific Gravity Range
	ml/24 hr			
1	1950	800-3265	1.014	1.005-1.028
2	1400	990-2350	1.019	1.013-1.029
3	1170	570-2200	1.022	1.006-1.031
4	1400	1080-1980	1.025	1.022-1.032
5	1470	1000-2035	1.020	1.010-1.028
6	1380	965-2090	1.023	1.007-1.030
7	2260	825-3725	1.015	1.003-1.024
8	1670	1140-2470	1.019	1.009-1.029
12	1560	1115-2010	1.022	1.015-1.030

Interpretation of these data is somewhat difficult, beyond the clear conclusions that the creatinine clearance is markedly affected by diet, and only slightly, if at all by water limitation. Beyond this, it is probable that a correlation existed between decrease in creatinine clearance and degree of caloric deficit. Correlations with nutrient mixture or solute load are difficult to detect, and are not convincing.

Our method was validated, and the conclusion concerning independence between creatinine clearance and water limitation was confirmed in a special experiment on two of the alternate subjects: The experiment is reported in full in Appendix II. Both subjects were on starvation, and in alternating periods had either water in liberal amounts, or else no water at all: Their glomerular filtration rates decreased markedly in starvation; they were not further reduced by total deprivation of water.

Assuming that a diminution in G.F.R. denotes impaired function of the kidney, our results allow the various nutrient combinations to be listed in rank-order. Previous workers have detected changes when the subject is deficient in sodium (Calcagno and Rubin, 1951; McCance and Widdowson, 1937; Chasis et al. 1950) and in low protein regimens (Rapoport et al., 1949). It is difficult to prove that either factor was operative in our subjects, although certainly, low protein and low salt diets were eaten.

Other features of creatinine metabolism are shown in Tables III. 74, III. 75 and III. 76. The serum creatinine was highest in pre-periods and recovery periods; within experimental periods it was highest in starvation and in 30/0/70 2000. It may be that two factors are operative: an increasing serum level with increasing creatinine in the body (either endogenous in starvation or exogenous

STAT
STAT

TABLE III. 71A

URINE VOLUME* (Mean and Range): UNLIMITED WATER
ml/24 hr

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	1820	1470	1480	1690
	1080-3725	790-2680	755-2520	675-3330
ST 0	1690	930	950	1910
	870-2480	155-1280	165-2040	700-3200
0/100/0	1500	900	669	1970
1000	935-2470	255-1315	280-1260	1000-2555
0/100/0	1470	920	1000	1420
2000	900-2350	345-1710	395-3220	810-2350
2/20/78	1600	740	440	1850
1000	1130-2035	515-1005	265-625	1615-2110
2/20/78	1110	420	490	1030
2000	1935-1325	280-510	330-680	775-1320
15/52/33	2050	940	980	1950
1000	1280-3265	430-1400	705-1910	1330-2480
15/52/33	1590	1310	1110	1590
2000	625-2460	615-3170	920-1960	1450-1805
30/0/70	1700	1670	1700	1980
1000	1320-2040	1120-2400	1120-2100	1595-2475
30/0/70	1400	1180	1250	1380
2000	1180-1620	1100-1280	930-1630	810-1695

*Day 1 of experimental and recovery periods omitted; also days on which water diuresis tests were performed.

in diet), and a decreasing level with increased calories.

Urinary excretion of creatinine in pre-periods is summarized in Table III. 75 for the individual subjects. The range between subjects was from 2.28 gm/day to 3.12 gm/day, which is a reasonable figure considering the literature on the subject (Consolazio et al., 1951). Inspection of Table III. 76 shows that creatinine excretion tended to be highest in pre-periods and recovery periods. During experimental periods (second week) it was highest for 30/0/70 and lowest for starration. There is a fair correlation between increasing creatinine excretion and increasing protein intake.

We cannot confirm from our data any true constancy of creatinine excretion even when the subject was on a constant regimen. This finding casts doubt upon a practice that is common in some metabolic wards; i.e., assuming that the creatinine excretion is constant for a given subject, and using this assumed figure as a measure of completeness of urine collections on the part of the subjects and laboratory attendants.

TABLE III. 71B

URINE VOLUME* (Mean and Range): LIMITED WATER
ml/24 hr

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	1390	600	610	1940
	870-2835	315-1030	330-1060	740-2960
ST 0	1620	660	510	1790
	1130-2150	300-930	195-690	1070-2810
0/100/0	1440	390	290	2000
1000	1080-3115	220-700	230-335	930-3115
0/100/0	1630	370	260	1460
2000	870-3830	190-890	215-370	990-2810
2/20/78	1500	520	320	1800
1000	1250-2930	395-1700	295-890	1510-2040
2/20/78	1460	560	350	1430
2000	1115-1930	330-930	255-670	1065-2330
15/52/33	1360	560	330	1530
1000	1005-1700	385-910	350-620	955-1585
15/52/33	1360	560	415	1030
2000	970-2270	300-930	300-730	1100-1460
30/0/70	2680	920	790	1940
1000	2200-3060	415-930	695-930	2435-2670
30/0/70	2260	860	704	2270
2000	760-2835	6 -1460	590-955	1195-2380

*Day 1 of experimental and recovery periods omitted; also days on which water diuresis tests were performed.

In summary, we find that various measurements of creatinine in serum and urine reveal fluctuations that are correlated with different regimens, and are susceptible of quantitative rank-ordering. Probably the most meaningful of these, according to current concepts, is the creatinine clearance; it is closely related to renal function.

Osmotic Clearance. Two major and related functions of the kidney are the regulation of osmotic balance and the ultimate control of water balance in the body. Two general questions are to be answered in relation to the present data. First, is the osmotic clearance related to the nutrient mixture as well as to dehydration? Second, is the minimal urine excretion related to the solute load imposed by the various nutrient mixtures? These questions may be answered by inspection of Figures III. 30 and III. 31, and by certain calculations made from them. We are greatly indebted to Dr. H. W. Smith for his kind assistance in this phase of the study.

STAT
STAT

TABLE III. 72A

URINARY SPECIFIC GRAVITY* (Mean and Range): UNLIMITED WATER
Corrected to 15.6°C

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	1.019	1.020	1.021	1.021
	1.003-1.026	1.008-1.031	1.011-1.039	1.009-1.031
ST 0	1.018	1.017	1.015	1.017
	1.008-1.031	1.006-1.029	1.004-1.029	1.003-1.027
0/100/0	1.019	1.014	1.014	1.019
1000	1.009-1.029	1.006-1.032	1.006-1.024	1.016-1.024
0/100/0	1.022	1.013	1.013	1.026
2000	1.013-1.030	1.007-1.024	1.001-1.031	1.019-1.033
2/20/78	1.016	1.013	1.024	1.018
1000	1.010-1.027	1.009-1.025	1.011-1.030	1.012-1.021
2/20/78	1.024	1.023	1.021	1.026
2000	1.017-1.026	1.021-1.025	1.013-1.027	1.018-1.031
15/52/33	1.018	1.018	1.012	1.022
1000	1.007-1.028	1.007-1.031	1.005-1.022	1.009-1.032
15/52/33	1.023	1.022	1.022	1.021
2000	1.017-1.032	1.012-1.031	1.011-1.030	1.016-1.024
30/0/70	1.021	1.015	1.011	1.018
1000	1.016-1.029	1.006-1.019	1.008-1.015	1.008-1.028
30/0/70	1.020	1.020	1.024	1.019
2000	1.018-1.024	1.019-1.023	1.019-1.027	1.010-1.023

*Day 1 of experimental and recovery periods omitted; also days on which water diuresis tests were performed.

One of the most closely guarded concentrations in the body is that of the serum osmolarity, which is the resultant of the effects of all osmotically active molecules and ions in the serum. In our subjects in pre-periods the serum osmolarity was about 0.3 osmols/liter, and showed very small deviations from time to time (Table III. 77); figures typical according to the literature (Smith, 1951). These data were derived from direct measurement by the freezing point technique. Almost identical results were obtained when the osmolarity was calculated from the known concentrations of sodium, potassium, chloride, urea, and glucose in the serum. Since we used both approaches in arriving at our data, this validation is important.

Figure III. 30 shows graphically the correlation between urine volume and the osmolar urine/serum ratio. In the calculation of clearance, osmolar clearance would equal (U/S) x (Urine Volume). By plotting U/S against Urine Volume one is able to draw conclusions concerning the possible functional implications of both as they relate to the kidney. Day by day results are plotted for four

TABLE III. 72B

URINARY SPECIFIC GRAVITY* (Mean and Range): LIMITED WATER
Corrected to 15.6°C

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	1.022	1.030	1.029	1.017
	1.81-1.028	1.013-1.037	1.021-1.035	1.009-1.035
ST 0	1.021	1.023	1.024	1.020
	1.017-1.029	1.014-1.032	1.019-1.031	1.012-1.028
0/100/0	1.018	1.028	1.031	1.019
1000	1.013-1.027	1.016-1.033	1.026-1.035	1.010-1.026
0/100/0	1.018	1.025	1.027	1.024
2000	1.006-1.027	1.020-1.030	1.023-1.034	1.019-1.037
2/20/78	1.022	1.029	1.035	1.022
1000	1.007-1.027	1.017-1.029	1.022-1.040	1.018-1.026
2/20/78	1.023	1.023	1.031	1.022
2000	1.019-1.028	1.020-1.031	1.019-1.032	1.019-1.028
15/52/33	1.020	1.027	1.029	1.024
1000	1.016-1.025	1.011-1.031	1.027-1.035	1.017-1.029
15/52/33	1.024	1.033	1.028	1.022
2000	1.013-1.030	1.026-1.039	1.027-1.029	1.017-1.027
30/0/70	1.014	1.026	1.029	1.010
1000	1.008-1.020	1.023-1.031	1.026-1.035	1.007-1.013
30/0/70	1.013	1.026	1.024	1.013
2000	1.009-1.019	1.022-1.030	1.021-1.028	1.010-1.020

*Day 1 of experimental and recovery periods omitted; also days on which water diuresis tests were performed.

conditions in which the solute load was high (positive control), moderately high (starvation and meat bar-cereal biscuit) and very low (pure carbohydrate), under regimens of limited and unlimited water intake.

Average weekly data are shown in Figure III. 31 for the other major conditions of the study (pre-period and recovery, high fat, and meat bar alone). Although the variations were not so extreme as they were seen daily data were plotted, nevertheless it is possible to notice differences that are interpretable.

In all conditions, the curves follow a somewhat exponential path, asymptotes being approached at the largest urine volumes and the smallest. The exact position of the curves was related to the total solute load imposed by the particular ration, being raised with the higher solute loads. For the positive control, starvation, and the meat bar-cereal biscuit the minimum U/S ratio was in the neighborhood of 1.0; for the pure carbohydrate diet, it was 0.1.

STAT

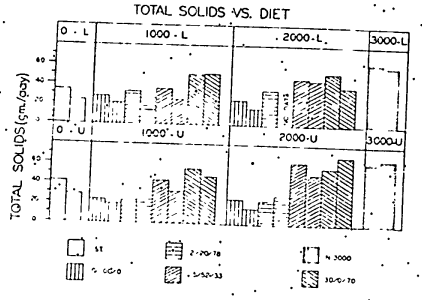

FIGURE III. 28. URINARY TOTAL SOLIDS VS. DIET

TABLE III. 73

PRE-PERIOD DATA ON ENDOGENOUS CREATININE CLEARANCE

Subject No.	Serum Creatinine M	σ	C.V.	Creatinine Clearance M	σ	C.V.	M
	mg/100ml	mg/100ml	%	ml/min	ml/min	%	ml/min/1.73m^2
1	1.11	0.10	9.0	165	22	13.3	157
2	1.14	0.13	11.4	147	17	11.6	138
3	1.15	0.21	18.2	154	9	5.9	131
4	1.25	----	----	159	--	----	135
5	1.19	0.06	5.0	162	16	9.9	156
6	1.14	0.19	16.7	158	15	9.5	156
7	1.01	0.15	14.9	160	37	23.1	147
8	1.10	0.11	10.0	159	10	6.3	148
12	1.01	0.02	2.0	170	12	7.0	147

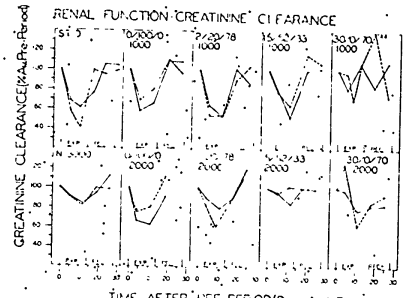

FIGURE III. 29. RENAL FUNCTION: "CREATININE" CLEARANCE AS DETERMINED BY 24-HOUR TEST.

Continuous Line, Unlimited Water; Dashed Line, Limited Water.

Two important conclusions may be derived from the present data. The first is that the human kidney is substantially more efficient in its osmotic clearance than has been thought previously. Previous workers have stated that the maximal human clearance ration U_{Osm}/S_{Osm} is 4.1 (e.g., Smith, 1951). Our subjects often had ratios far above this figure, ranging as high as 5.9. This represents an increase of 44% over previous estimates; and has important implications with respect to the solute economy of the human body. The kidney is much more efficient potentially in this respect than was thought previously.

The second important conclusion from our data is in regard to the so-called "minimum urine volume." Previous workers (e.g., Gamble) have calculated this figure after making numerous assumptions, the most important being that the maximum osmolar concentration in urine is 1.4 Osm/l. They have then computed the "minimum urine volume" by calculating the ratio (total solutes excreted)/(1.4). From our charts, the "minimum urine volume" can

STAT
STAT

TABLE III. 74

SERUM CREATININE
(Mean and Range, mg/100 ml)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	1.12	1.18	1.22	1.19
	1.00-1.35	1.00-1.37	1.00-1.50	0.90-1.35
ST 0	1.18	1.39	1.62	1.13
	0.90-1.37	1.00-1.58	1.35-2.15	1.00-1.35
0/100/0	1.09	1.20	1.27	1.16
1000	1.00-1.16	1.00-1.35	1.00-1.35	1.05-1.25
0/100/0	0.98	1.14	1.12	0.94
2000	0.90-1.00	1.00-1.25	1.00-1.16	0.90-1.05
2/20/78	1.16	1.30	1.31	1.00
1000	1.16	1.25-1.35	1.25-1.37	1.00
2/20/78	1.10	1.00	1.10	1.02
2000	1.05-1.16	1.00	1.05-1.16	1.00-1.05
15/52/33	1.19	1.12	1.46	1.09
1000	1.00-1.35	1.00-1.25	1.35-1.77	1.00-1.16
15/52/33	0.95	1.18	1.25	1.19
2000	0.85-1.05	1.05-1.35	1.00-1.37	1.16-1.25
30/0/70	0.98	1.36	1.24	1.15
1000	0.90-1.05	1.35-1.37	1.16-1.37	1.05-1.25
30/0/70	1.10	1.58	1.96	1.16
2000	1.05-1.16	1.50-1.67	1.77-2.15	1.16

TABLE III. 75

PRE-PERIOD DATA FOR URINARY CREATININE

Subject No.	Creatinine, gm/24 hr M	σ	C.V. %
1	2.85	0.37	13.0
2	2.52	0.21	8.3
3	3.10	0.68	21.9
4	3.12	----	----
5	2.77	0.25	9.0
6	2.60	0.34	13.1
7	2.28	0.41	18.0
8	2.55	0.40	15.7
12	2.69	0.06	2.2

TABLE III. 76

URINARY CREATININE
(Mean and Range, gm/24 hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	2.70	2.44	2.27	2.60
	1.98-3.33	1.98-2.78	1.76-2.76	2.43-2.85
ST 0	2.67	1.94	1.78	2.55
	2.16-3.30	1.55-2.16	1.39-2.04	1.93-3.02
0/100/0	2.59	1.90	1.72	2.69
1000	2.32-2.74	1.02-1.59	1.86-1.98	2.53-2.80
0/100/0	2.67	1.62	1.80	2.15
2000	2.46-2.92	1.78-2.06	1.46-1.98	1.73-2.40
2/20/78	2.95	1.77	1.90	2.20
1000	2.87-3.03	1.67-1.86	1.81-1.70	2.04-2.36
2/20/78	2.98	1.99	1.78	2.15
2000	2.53-2.64	1.98-2.00	1.73-1.83	1.98-2.32
15/52/33	2.45	2.21	1.99	2.67
1000	2.32-2.76	1.98-2.45	1.76-2.34	2.39-2.91
15/52/33	2.98	2.56	2.56	2.61
2000	1.67-4.16	2.26-2.76	2.34-2.90	2.46-2.87
30/0/70	2.58	2.94	4.04	2.48
1000	2.36-2.81	2.82-3.06	----	1.46-3.50
30/0/70	2.37	3.09	3.06	2.16
2000	2.21-2.53	3.46-4.32	2.59-3.52	2.00-2.33

TABLE III. 77

MEAN SERUM OSMOLAR CONCENTRATION
FOR EIGHT SUBJECTS: 27 April-13 June 1953

Subject No.	Total Observations	Serum Osmolarity Osm/l	σ
1	6	0.32	0.03
2	6	0.31	0.02
3	6	0.32	0.02
5	7	0.29	0.02
6	7	0.33	0.04
7	7	0.32	0.03
8	7	0.31	0.04
12	6	0.30	0.02

be estimated without making any assumptions. The left limb of the curves approaches an asymptote which is the "minimum urine volume" for each condition. For the positive control, it is 740 ml/day; for the meat bar-cereal biscuit combination it is 380 ml/day; and for the pure carbohydrate diet, it is 225 ml/day. This latter agrees well with the figures reached by Gamble (1946-47) and Roth (1948), who used the assumptions outlined above. The general conclusions to be reached is that those nutrient mixtures which impose the least osmotic load, impose the least obligatory water requirement for excreting this load. In this respect clearly carbohydrate and fat are the most desirable components over a short period of time. However, on longer periods of such regimens, or when sweating is profuse, upsetting of the body's protein and electrolyte balances might be a potential hazard.

Our data for starvation and total water deprivation are shown in both figures. A pattern similar to that of the other conditions is noticeable, although the data are fewer in number than for the other conditions; the subjects were able to withstand only about three days of combined total deprivation of water and calories. It would appear that the isoosmolar ratio, 1.0, is approached as the abscissa for U/S ratio although it was never actually reached by our subjects. The asymptote representing "minimum urine volume" would appear to be about 500 ml/day in starvation.

Two other matters of substantial interest with respect to water and solute economy were also investigated. The first was the regulation of serum osmolar concentration; the second, the relationship between total solids in the urine and the osmotic pressure of the urine.

It is a well established principle that the body protects the serum osmolar concentration at the expense of extracellular and intracellular fluids and solutes. Our subjects showed remarkable

CAPTION FOR FIGURES III. 30 and III. 31
URINE/SERUM OSMOTIC RATIO VS. SOLUTE LOAD

The figures represent data from regimens in which solute loads and water intakes were widely different. Circles around symbols for individual subjects represent limitation of water during that regimen.

Subject No.	Symbol	Subject No.	Symbol
5	×	2	□
6	+	3	◇
7	△	12	△
8	▽	9	▽
1	●	11	■

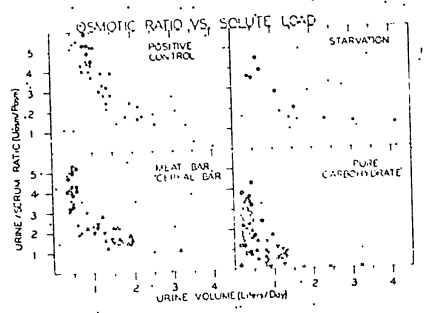

FIGURE III. 30

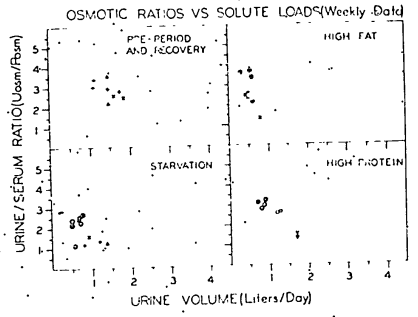

FIGURE III. 31

STAT
STAT

constancy of the serum osmolarity. Even in extreme dehydration, when the hematocrit was high, the standard deviation of values for the serum osmolarity was very small. Thus, in spite of varying solute loads at varying degrees of dehydration, this most important of homeostatic manifestations was well protected.

The relationship between total urinary solids and urinary osmotic pressure may be dispensed with summarily. No significant correlation between the two could be found, the osmotic pressure being determined by freezing point depression and the total solids being computed from specific gravity according to Haser's equation. Therefore, the total solids cannot be used to give information on osmotic relationships.

In order to draw conclusions concerning the relative effects of different nutrient mixtures on water and osmotic economies, it is necessary to establish certain generalization on what is beneficial and what is potentially harmful. We propose that consideration has to be given to three important variables: the clinical condition of the subjects, the osmotic ratio, and the "minimum urine volume". Previous workers (e.g., Gamble, Roth), have considered that mixture to be best which necessitates the least "minimum urine volume". We consider this single criterion to be inadequate, inasmuch as one subject may be developing clinically demonstrable difficulties when another, with the same minimum urine volume, may be surviving two weeks without clinically demonstrable distress. Actual examples of this were seen in the present studies with respect to the positive control ration and the meat bar-cereal biscuit combination. In the first case two subjects had identical minimum urine volumes of about 750 ml/day. Subject 6, on limited water developed a U/S ratio of as high as 5.9, and was close to dehydration exhaustion when he had to be relieved by transfer to unlimited water. Subject 5, on unlimited water; remained in good condition with a U/S ratio of 4 to 4.5. During the meat bar-cereal biscuit regimen, the "minimum urine volumes" of Subjects 8 and 6 were identical at 500 ml/day. On limited water, Subject 8 developed potentially dangerous symptoms of lumbar pain, cessation of sweating, and pathological weakness at a U/S ratio of 5.0; all of these symptoms were relieved when he was transferred to unlimited water. On unlimited water Subject 6 remained in good condition throughout at a U/S ratio of 3 to 3.5.

An interesting situation arose with the pure carbohydrate diet. Thirst was minimal, and none of the subjects developed pronounced clinical symptoms, whether on limited or unlimited water. Nevertheless, signs of renal pathology did occur. At low urine volumes, red cells and hyaline casts were detected in the urine of all subjects. Whenever red cells thus appear, it is a sign of some renal involvement. In other ration mixtures, red cells were only found in the urine of subjects who showed detectable clinical symptoms of distress.

We conclude that whenever the U/S ratio reaches 4.5 it is likely that the subject is going to become incapacitated in the near future, especially when the urine volume is at the minimum level.

From the standpoint of maximal body efficiency, that ration is best which produces no clinical symptoms. From the standpoint of renal work and renal function that ration is best which does not lead to red cells and casts in the urine, and which keeps the U/S ratio in the neighborhood of 1.0, the isosmotic level at which renal work is minimal. From the standpoint of water economy, that ration mixture is best which necessitates the least urine volume. By these various criteria, the pure carbohydrate diet was best -- but red cells did appear in the urine during this regimen.

Urea Nitrogen. The urea in the blood is known to change in its concentration in relation to two major factors: the first is protein intake, the second is kidney function (Smith, 1952). This compound was studied systematically in our subjects as being a possible measure of kidney function, and possibly as related to the several nutrient combinations.

The usual concentration of urea nitrogen is shown for all subjects in the pre-periods in Table III. 78. The value of 10 to 15 is considered normal by clinical pathologists, and our subjects fell within this normal range. From time to time the subject showed individual variations, but these were quite small, as shown by the moderate coefficients of variation.

TABLE III. 78

PRE-PERIOD DATA FOR SERUM UREA NITROGEN
(mg/100 ml)

Subject No.	Mean	σ	C.V. %
1	13.1	2.2	16.8
2	13.2	1.6	12.1
3	15.3	1.6	10.5
4	11.1	---	----
5	10.8	0.5	4.5
6	12.6	1.5	11.9
7	11.9	2.2	18.4
8	9.1	1.1	12.1
12	10.3	0.9	8.7

During the experimental periods, changes were observed that could be correlated with the different regimens, as may be seen in Figure III. 32. The urea concentration was always higher for a given nutrient combination when water was restricted than it was

STAT
STAT.

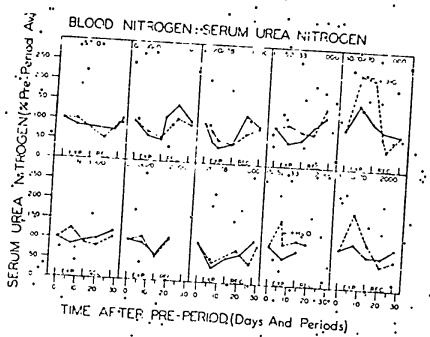

FIGURE III. 32. BLOOD NITROGEN: SERUM UREA NITROGEN. Continuous Line, Unlimited Water; Dashed Line, Limited Water.

when water intake was unlimited. Usually these differences were small, but in 30/0/70 they were very striking at both 1000 and 2000 Cal/day. The least striking differences related to water restriction were seen in regimens of low protein intake - starvation, 0/100/0 and 2/20/78. They were intermediate for N 3000 and 15/52/33. These findings would lead to the supposition that the blood urea nitrogen is a very sensitive index of dehydration when nitrogen intake is substantial, but less so when nitrogen intake is low.

There was a noticeable tendency for the blood urea nitrogen to decrease during regimens when the nitrogen intake was very low, as in 0/100/0 and 2/20/78, to rise when the protein intake was high in 30/0/70, and to be little affected when protein intake was moderate as in N 3000 and 15/52/33. Starvation results in endogenous degradation of tissue protein, and it is probable that the effects of 0/100/0 and 2/20/78 resulted from tissue sparing.

In summary, the blood urea nitrogen proved to be correlated with the nutrient intake and to be a sensitive correlate of dehydration when protein intake was moderate to high. In fact, the

changes were so marked in the latter regimens, that clinically speaking one might suspect pathological nitrogen retention in the body.

Addis Count. In 1925, Addis proposed to make quantitative a diagnostic technique that has long been widely used in the study of kidney disease; observation of the casts, red blood cells, leukocytes, and epithelial cells in the urine. Instead of qualitative examination of the urinary sediment, he proposed quantitative measurement of the night specimen collected for 12 hours. When hemorrhagic nephritis is present, red cells predominate; during infections white cells and epithelial cells predominate; and casts of different kinds may be present in some stages of some kinds of renal involvement.

We settled upon a modification of the Addis count, namely qualitative examination of the urine collected during the two-hour test in the day. Therefore, our data are comparable internally, but are not directly comparable with results in the literature when the original Addis count was used.

The pre-period means and ranges for all subjects are shown in Table III. 79. Casts and red cells were absent. A very large

TABLE III. 79

ADDIS COUNT: PRE-PERIOD MEANS AND RANGES

cells x 10^3/2 hr

Subject No.	Casts Mean	Casts Range	Red Blood Cells Mean	Red Blood Cells Range
1	0	-	0	-
2	0	-	0	-
3	0	-	0	-
4	-	-	-	-
5	0	-	0	-
6	0	-	0	-
7	0	-	0	-
8	0	-	0	-
12	0	-	0	-

Subject No.	Leukocytes Mean	Leukocytes Range	Epithelial Cells Mean	Epithelial Cells Range
1	1,550.6	105.6-3,333.0	213.1	61.5-436.8
2	33.4	0-94.0	75.9	14.1-230.4
3	11.6	0-35.8	159.9	12.2-230.0
4	--	--	--	--
5	17.6	0-65.2	28.9	0-74.5
6	39.4	0-170.4	37.9	5.8-85.2
7	40.0	0-118.8	96.0	0-237.6
8	3.7	0-22.2	11.2	0-24.0
12	6.8	0-12.2	65.3	12.2-235.0

STAT

variation from subject to subject was seen in leukocytes and epithelial cells. Subject 1 was exceptional, and his data must be explained on clinical grounds; he was known to have had a urethral infection shortly before the experiment started. Leaving out his data, the range for leukocytes was from 0 to 170 cells x 10^3 per 2 hours, and for epithelial cells it was 0 to 280 cells x 10^3 per 2 hours.

During the experimental periods, casts appeared in three regimens: starvation, 0/100/0 2000, and 15/52/33 1000 in that order as regards quantity (Table III. 80). A few red cells appeared in four regimens: starvation, 0/100/0 1000, 0/100/0 2000, and 30/0/70 1000 in the first week only (Table III. 81).

TABLE III. 80

ADDIS COUNT I. CASTS
(Mean and Range, cells/2 hr)

Nutrient Mixture	Pre-Period	Experimental I	II	Recovery
N 3000	0	0	0	0
	–	–	–	–
ST 0	0	49,950	140,585	0
	–	0-210,000	0-529,000	–
0/100/0	0	0	0	0
1000	–	–	–	–
0/100/0	0	2,630	31,630	0
2000	–	0-5,460	0-61,800	–
2/20/78	0	0	0	0
1000	–	–	–	–
2/20/78	0	0	0	0
2000	–	–	–	–
15/52/33	0	930	2,000	0
1000	–	0-3,720	0-8,600	–
15/52/33	0	0	0	0
2000	–	–	–	–
30/0/70	0	0	0	0
1000	–	–	–	–
30/0/70	0	0	0	0
2000	–	–	–	–

In view of the diagnostic and prognostic weight that must be given clinically to these formed elements, a close scrutiny of the results is rewarding. In general, it was starvation and the pure carbohydrate diet that produced positive changes. The individual data for starvation are shown in Table III. 82. Subjects 2, 12, 6 and 8 had limited water. In all four subjects with limited water, casts appeared; this happened in three of the subjects on unlimited water. In one of four subjects on limited water, red cells appeared; in two of four subjects on unlimited water, this

TABLE III. 81

ADDIS COUNT II. RED BLOOD CELLS
(Mean and Range, cells/2 hr).

Nutrient Mixture	Pre-Period	Experimental I	II	Recovery
N 3000	0	0	0	0
	–	–	–	–
ST 0	0	7,340	595	0
	–	0-[illegible],800	0-3,770	–
0/100/0	0	1,950	3,[illegible]0	0
1000	–	0-3,620	0-3,825	–
0/100/0	0	1,[illegible]75	1,160	0
2000	–	0-7,500	0-2,400	–
2/20/78	0	0	0	450
1000	–	–	–	0-8.1
2/20/78	0	0	0	0
2000	–	–	–	–
15/52/33	0	0	0	0
1000	–	–	–	–
15/52/33	0	0	0	0
2000	–	–	–	–
30/0/70	0	4.0	0	0
1000	–	0-8.0	–	–
30/0/70	0	0	0	0
2000	–	–	–	–

happened. Therefore, it seems likely that starvation, not water limitation led to the appearance of casts.

When one examines the same phenomena for the pure carbohydrate regimens, one finds the following picture from Table III. 83. Subjects 6, 8, 2, and 12 were unlimited in water consumption, and subjects 5, 7, 1 and 3 were limited.

Limited Water

Casts: 1 of 4 subjects
Red cells: 2 of 4 subjects

Unlimited Water

Casts: 2 of 4 subjects
Red cells: 1 of 4 subjects

It appears unlikely again that water restriction was responsible for the results.

Leukocytes and epithelial cells are considered in Tables III. 84 and III. 85. Leukocytes increased most strikingly in starvation,

TABLE III. 82

TWO-HOURLY URINARY EXCRETION OF FORMED ELEMENTS
DURING STARVATION BY INDIVIDUAL SUBJECTS

	Subject 1			Subject 2			Subject 3			Subject 12		
	Day	Casts*	R.B.C.	Day	Casts*	R.B.C.	Day	Casts*	R.B.C.	Day	Casts*	R.B.C.
Pre-Period	4	0	0	4	0	0	4	0	0	4	0	0
Starvation	4	0	5,900	4	7,992	0	4	0	0	4	0	0
Starvation	11	238,000	0	11	180,000	0	9	2,770	2,770	9	30,200	0
Post-Period	7	0	0	4	0	0	9	0	0	9	0	0

	Subject 5			Subject 6			Subject 7			Subject 8		
Pre-Period	5	0	0	4	0	0	5	0	0	5	0	0
Starvation	4	216,000	0	5	158,000	52,000	5	0	0	5	17,200	0
Starvation	-	-	-	9	529,000	0	10	0	0	8	4,130	0
Post-Period	7	0	0	3	0	0	2	0	0	4	0	0
	15	0	0	10	0	0	9	0	0	11	0	0

*Only hyaline casts observed.

TABLE III. 83

TWO-HOURLY URINARY EXCRETION OF FORMED ELEMENTS
DURING PURE CARBOHYDRATE REGIMEN BY INDIVIDUAL SUBJECTS

A. 1000 Cal/day

	Subject 5			Subject 6			Subject 7			Subject 8		
	Day	Casts	R.B.C.	Day	Casts	R.B.C.	Day	Casts	R.B.C.	Day	Casts	R.B.C.
Pre-Period	5	0	0	5	0	0	5	0	0	5	0	0
Experimental	5	0	2,367	5	0	3,620	5	0	0	5	0	0
Experimental	12	0	0	12	0	3,345	12	0	2,480	12	0	0
Post-Period	7	0	0	7	0	0	5	0	0	5	0	0

B. 2000 Cal/day

	Subject 1			Subject 2			Subject 3			Subject 12		
Pre-Period	4	0	0	2	0	0	2	0	0	4	0	0
Experimental	4	0	7,590	4	5,460	0	4	3,000	0	4	0	0
Experimental	11	0	2,490	11	64,800	0	11	5,000	0	11	7,725	0
Post-Period	4	0	0	4	0	0	4	0	0	4	0	0

STAT
STAT

Declassified in Part - Sanitized Copy Approved for Release @ 50-Yr 2014/02/19 : CIA-RDP81-01043R003700220001-2

TABLE III. 84

ADDIS COUNT III: LEUKOCYTES
(Mean and Range, cells x 10^3/2 hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	15.7	20.2	14.2	10.3
	0-65.2	0-57.5	0-25.2	0-22.0
ST 0	19.1	35.7	90.7	23.6
	0-96.0	0-144.0	0-333.0	0-122.8
0/100/0	14.4	104.6	156.5	3.7
1000	0-22.2	11.2-248.8	10.8-238.0	0-14.2
0/100/0	133.0	180.4	447.0	30.1
2000	0-252.0	45.6-564.0	54.0-1,530.0	0-1,180.0
2/20/78	0	72.9	54.6	4.0
1000	---	4.2-141.6	13.2-96.0	0-8.1
2/20/78	24.0	2.3	49.2	0
2000	12.2-35.8	0-5.7	0-98.5	---
15/52/33	491.5	13.5	30.4	17.1
1000	12.6-1,835.0	0-40.8	3.6-77.0	0-42.3
15/52/33	0	187.0	12.2	2.1
2000	---	0-720.0	0-28.9	0-6.4
30/0/70	6.2	78.4	53.6	9.9
1000	0-12.5	40.0-116.8	11.6-115.2	0-19.8
30/0/70	85.5	840.2	164.6	37.6
2000	25.6-145.6	560.0-1,190.0	8.3-321.0	24.5-50.6

0/100/0 1000, 0/100/0 2000, and 30/0/70 2000. Epithelial cells increased most strikingly in 0/100/0 2000, 30/0/70 1000 and 30/0/70 2000. These results are to be compared with those for casts and red cells, the 0/100/0 regimens being common to both groups of data.

In drawing conclusions from these data, one must be cautious. It is probably safe to say that some experimental regimens caused an increase in the formed elements of the urine irrespective of water consumption. Prominent in this respect was the pure carbohydrate diet. In terms of deleterious effects, it must be assumed on clinical grounds, and in view of the classical interpretation of such data, that the ration that produces these changes is less desirable in some way than those that do not.

3. Gastrointestinal Function

The Characteristics of the Feces. An aspect of body function which has not been adequately explored in previous investigations on survival rations is that of the feces. Frequently this material is not collected and even when it is, the stool is immediately prepared for chemical analysis without prior gross or microscopic study. This situation is unfortunate, for many significant findings should accrue from close attention to this excretion.

TABLE III. 85

ADDIS COUNT IV. EPITHELIAL CELLS
(Mean and Range, cells x 10^3/2 hr)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	42.6	32.4	38.5	12.0
	0-240.0	0-240.6	11.4-115.6	0-96.5
ST 0	49.6	70.5	5.6	15.1
	0-111.5	0-210.0	0-151.2	2.4-232.8
0/100/0	10.4	31.4	65.3	117.6
1000	0-22.	3.7-67.0	21.0-159.5	14.9-317.0
0/100/0	23.6	46.3	177.5	18.1
2000	12.2-61.5	10.1-101.0	8.0-139.0	7.9-37.0
2/20/78	62.4	41.0	28.0	28.6
1000	30.1-71.5	17.0-71.0	8.0-156.0	16.2-41.0
2/20/78	110.1	9.5	96.4	22.1
2000	12.2-216.0	5.7-13.2	11.3-38.5	21.2-23.1
15/52/33	27.9	12.3	14.4	33.0
1000	21.6-2 .0	7.6-20.4	4.0-2 .4	0.8-85.2
15/52/33	7.2	63.4	30.4	17.1
2000	0-11.3	3.7-216.0	11.4-61.2	0-38.4
30/0/70	113.9	100.2	137.7	191.9
1000	0-226.0	69.1-1 .0	91.2-209.5	26.5-357.0
30/0/70	333.6	163.9	109.5	94.0
2000	230.-436.9	32.9-273.0	61.1-278.0	36.7-151.2

Seven-day collections of the feces were regularly made in the case of each subject. The color of the stools was noted, the wet weight recorded, and then the material was homogenized with a volume of water in a mixing blender. An aliquot was subjected to quantitive and qualitive chemical analysis and microscopic examination.

The color of the feces was at all times brown. At no time were clay-colored stools or bloody stools, or black stools passed.

In consistency the stools were generally well formed. Several episodes of loose stools developed in which the consistency ranged from soft to watery. The clinical aspects will be discussed below. No inspissated stools characteristic of constipation were passed even though the low-residue content of most of the experimental regimens was correlated with a sharp decrease in the frequency of bowel movements. No fretty, foul smelling stools were observed, although the stools from subjects on 30/0/70 had an odor somewhat reminiscent of the meat bar.

The wet weight of the feces: The average daily wet weight of the feces during the several periods of this experiment has been

summarized in Table III. 86. During pre-periods these weights ranged from 100 to 172 gm, during recovery periods from 100 to 266 gm and during experimental periods from 26 to 124 gm. Inspection of the table suggested that the average daily output of feces was a function of the total daily caloric intake. A plot of the data (Figure III. 33) demonstrated clearly that the greater the intake of food the greater was the bulk of the feces. This linear relationship between weight of feces and caloric intake suggested that none of the experimental diets, in spite of their low residue, caused any unexpected alterations in the weight of the stools; i.e., no combination of foods was associated with an abnormally high or low output of feces.

TABLE III. 86

GASTROINTESTINAL FUNCTION: AVERAGE DAILY WET WEIGHT OF FECES DURING THE SEVERAL EXPERIMENTAL REGIMENS

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
	gm/day	gm/day	gm/day	gm/day
N 3000	158	124	121	136
ST 0	125	31	37	184
0/100/0 1000	152	26	50	180
0/100/0 2000	151	42	59	266
2/20/78 1000	100	36	36	199
2/20/78 2000	180	41	41	190
15/52/33 1000	131	72	72	224
15/52/33 2000	115	105	94	102
30/0/70 1000	172	40	72	227
30/0/70 2000	133	76	54	185

Fecal Fat. According to our data (Table III. 87) the daily output of fecal fat ranged from 3.3 to 11.5 gm, the extreme range being from 2.0 to 20.7 gm. These are clinically normal figures for adults consuming an adequate amounts of foods in a mixed diet. The experimental regimens caused some marked alterations in the total fecal fat: on all of the mixtures, except positive control, there was a diminution. However, the surprising finding was that there was no close relationship between fecal fat and fat intake; rather the fecal fat output was a function of the total daily fecal weight. A plot of the data (Figure III. 34) demonstrated a linear relationship between fecal fat and total caloric intake. Evidently the fecal output of fat, at least in so far as our subjects were concerned, was a function of the output of feces per se (c.f., Figure III. 33). No subject excreted an abnormal amount of fecal fat during the experimental periods indicating that the abnormally high percentage of fat in the 30/0/70 and 2/20/78 diets was handled normally by the gastrointestinal tract. In recovery periods the output of fecal fat again increased and

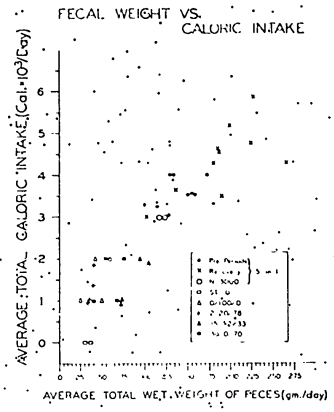

FIGURE III. 33. FECAL WEIGHT VS. CALORIC INTAKE

TABLE III. 87

PRE-PERIOD DATA FOR FECAL FAT
(Mean and Range, gm/day)

Subject No.	Total Fecal Fat Mean	Range
1	7.5	3.6-12.0
2	5.4	2.0-10.1
3	11.5	2.5-20.7
4	3.3	2.4-4.1
5	3.4	2.7-4.5
6	7.4	4.7-17.3
7	9.2	3.8-15.1
8	4.1	2.3-5.3
12	5.5	3.9-8.0

there were several values greater than 20.0 gm/day (Table III. 88). This increased output was probably merely an expression of the greater output of feces during this period (Table III. 86).

Qualitative analysis of the fecal specimens was also done with Sudan IV stain for detecting fat. The observations are summarized

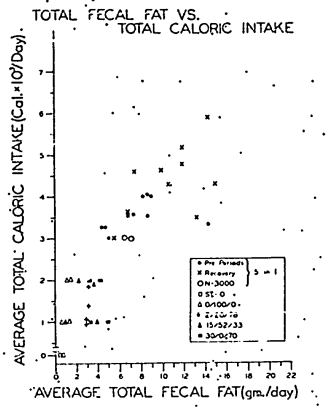

FIGURE III. 34. FECAL FAT VS. CALORIC INTAKE

in Table III. 89. Comparison of this table with Table III. 88 indicates a parallel behavior in the qualitative and quantitative tests. The striking exceptions are the +3 records for the experimental periods for 2/20/78 2000. Although several +3 and +4 reactions were recorded, there is no quantitative proof that these stools contained abnormal quantities of fat.

Fat Absorption. The question is naturally raised: was the abnormally high proportion of fat in the 30/0/70 and 2/20/78 regimens absorbed by the gastrointestinal tract to the same extent as in those regimens wherein the proportion of fat was more nearly like that of the customary diet? The data summarized in Table III. 90 demonstrate that comparable absorption of fat took place during all experimental regimens. The unusually fatty diet did not appreciably alter this gastrointestinal function. Since fat absorption is regulated by the gall bladder (bile) and pancreas (lipases) the inference can be drawn that these functions of these organs were not seriously impaired.

Nitrogen Absorption. Examination of the data for fecal nitrogen (Table III. 14) demonstrates that abnormal output did not occur. The implication is that nitrogen absorption was not disturbed. The relative nitrogen absorption for the several nutrient mixtures has

TABLE III. 88

TOTAL FECAL FAT IN RELATION TO EXPERIMENTAL REGIMENS
(Mean and Range)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
	gm/day	gm/day	gm/day	gm/day
N 3000	6.8	6.5	7.1	6.8
	(2.0-18.9)	(2.7-16.5)	(4.8-11.8)	(3.5-16.8)
ST 0	5.0	0.5	0.6	8.0
	(2.7-6.7)	(0.1-1.0)	(0.4-1.0)	(2.9-14.0)
0/100/0	7.3	0.6	1.4	10.6
1000	(3.4-15.1)	(0.3-1.4)	(0.5-2.3)	(5.5-16.9)
0/100/0	8.6	1.2	1.4	15.0
2000	(3.9-12.4)	(0.5-3.0)	(0.6-3.0)	(13.0-24.2)
15/52/33	8.6	1.1	3.9	11.9
1000	(3.6-17.6)	(0.8-1.3)	(1.9-5.9)	(4.5-16.5)
15/52/33	4.6	1.6	2.2	5.5
2000	(2.4-9.9)	(2.4-5.7)	(1.9-2.5)	(1.5-10.0)
30/0/70	8.2	1.6	3.4	14.3
1000	(4.5-11.8)	(0.1-3.0)	(3.0-3.8)	(9.0-19.5)
30/0/70	8.9	4.3	3.2	7.4
2000	(7.8-10.1)	(3.2-5.3)	(3.1-3.2)	(7.1-7.8)
2/20/78	4.4	2.9	2.9	11.9
1000	(3.4-5.4)	(2.5-3.3)	(2.5-3.3)	(5.0-18.8)
2/20/78	14.3	3.1	3.1	13.2
2000	(8.0-20.7)	(0.2-6.0)	(0.2-6.0)	(3.0-23.4)

not yet been calculated. At the present time only qualitative data have been evaluated. The fecal specimens were examined microscopically for the presence of digested and undigested muscle fibers. The results tabulated in Table III. 91 indicate that in general there were no remarkable changes in the number of muscle fibers estimated per low power field (L.P.F.). Irrespective of the regimen the majority of these fibers were incompletely digested. Whether this finding is abnormal, we cannot say. Examination of stools from two normal individuals subsisting on their customary diet also showed a majority of undigested muscle fibers.

Occult Blood. A surprising finding of the investigation was the high percentage of stools which were positive for occult blood, collected during periods when 5-in-1 ration was being eaten, (Table III. 92). During the investigation the pooled fecal specimens were regularly tested for occult blood using benzidine dihydrochloride as the indicator. Eleven percent of 28 specimens were positive in the case of stools collected during experimental periods. The few positive reactions never exceeded an intensity of +1. The only positive reactions occurred during periods in which meat bar was a component of the diet. The percentage of

TABLE III. 89

QUALITATIVE ANALYSIS OF FECES: FAT BY SUDAN IV*

Nutrient Mixture	Pre-Period	I	II	Recovery
N 3000	(9) +(5) 2+(3) 3+(1)	(6) +(3) 3+(1)	(8) 2+(4) +(2) tr(1) 2+(5)	(7) +(4) tr(2) 2+(1)
ST 0	(11) tr(4) +(4) 2+(2) 3+(1)	(4) 0(1) tr(2) +(1)	(1) 0(1)	(12) 0(2) tr(2) +(6) 2+(2)
0/100/0 1000	(3) 2+(3)	(3) 0(3)	(3) 0(1) tr(2)	(4) +(1) 2+(2) 3+(1)
0/100/0 2000	(4) tr(1) +(1) 2+(1) 3+(1)	(4) tr(3) +(1)	(4) tr(3) 2+(1)	(4) tr(1) +(1) 2+(2)
2/20/78 1000	----	----	----	(2) tr(2)
2/20/78 2000	(2) 2+(2)	(2) tr(1) 3+(1)	(1) 3+(1)	(3) 2+(2) 4+(1)
15/52/33 1000	(1) +(1)	(1) tr(1)	(2) tr(1) 2+(1)	(4) +(1) 2+(1) 3+(1)
15/52/33 2000	(6) tr(1) +(2) 2+(2) 3+(1)	(4) 0(1) tr(3)	(3) 0(2) tr(1)	(3) +(3)
30/0/70 1000	(2) 2+(2)	(2) 0(1) +(1)	(2) tr(1) +(1)	(2) +(1) 3+(1)
30/0/70 2000	(2) +(1) 2+(1)	(1) tr(1)	(1) 0(1)	(1) 2+(1)

*Numbers in parenthesis indicate number of specimens examined or specimens showing various reactions.

positive stools collected during subsistence on 5-in-1 ranged from 79 to 100%. The intensity of the reactions in many cases was greater than +1. Because of this remarkable finding it was imperative to prove whether or not this positive reaction represented true blood loss via the gastrointestinal tract or a false positive reaction due to the presence of a peroxidase-like material either in the food eaten or in the digestive products. Loss of blood

TABLE III. 90

FAT ABSORPTION IN RELATION TO EXPERIMENTAL REGIMENS
(Range, as Percent of Intake)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	94.0-97.6	87.4-96.6	92.9-96.7	94.0-97.3
ST 0	93.9-98.0	---	---	91.6-97.6
0/100/0 1000	93.3-96.5	---	---	91.1-97.0
0/100/0 2000	91.7-97.3	---	---	91.3-94.8
15/52/33 1000	92.2-98.0	96.6-97.9	94.4-95.0	92.1-99.0
15/52/33 2000	94.3-98.2	92.7-97.1	95.8-97.6	92.8-98.5
30/0/70 1000	92.7-96.8	96.0-99.9	94.9-96.0	92.7-99.1
30/0/70 2000	94.1-95.4	96.5-97.9	97.9-98.0	95.9-96.1
2/20/78 1000	96.2-96.8	96.4-97.3	96.3-96.5	92.2-97.8
2/20/78 2000	87.7-98.4	96.6-99.9	95.2-99.6	89.6-97.6

TABLE III. 91

QUALITATIVE ANALYSIS OF FECES: MUSCLE FIBERS/L.P.F.

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	8 2-20	10 4-20	10 2-30	7 2-15
ST 0	5 2-8	4 1-8	2 2-3	6 3-12
0/100/0 1000	10 6-15	8 1-20	14 10-20	9 1-20
0/100/0 2000	9 5-15	3 2¼	5 2-12	8 5-10
2/20/78 1000	-- --	-- --	-- --	15 10-20
2/20/78 2000	10 3-20	3 1-5	1 --	6 3-8
15/52/33 1000	4 4-5	2 --	8 7-10	5 3-15
15/52/33 2000	7 1-25	14 3-40	10 2-20	6 1-12
30/0/70 1000	10 7-15	6 5-7	8 5-12	5 2-8
30/0/70 2000	5 4-5	1 --	18 15-20	4 4-5

STAT
STAT

TABLE III. 92

EFFECT OF 5-IN-1 AND EXPERIMENTAL RATION COMPONENTS ON FECAL BENZIDINE REACTION

Ration	Stools Tested No.	Intensity of Benzidine Reaction 0	str	tr	1+	2+	3+	4+	% Positive
Fasting	5	5	0	0	0	0	0	0	0
Jelly bar, spice crops, hard candy	10	10	0	0	0	0	0	0	0
Meat bar	5	3	1	1	0	0	0	0	40
Chocolate bar	3	3	0	0	0	0	0	0	0
Meat bar, cereal biscuit	10	9	0	0	1	0	0	0	10
Total	28	25	1	1	1	0	0	0	11
5-in-1 (pre-period)	41	2	1	6	9	14	8	1	95
5-in-1 (positive control)	12	0	0	2	3	4	7	0	100
5-in-1 (recovery)	43	9	2	12	5	6	7	0	79

would seriously jeopardize individuals subsisting on 5-in-1 ration for any prolonged period of time.

The first approach to the solution of this problem was to find out if all subjects reacted alike to the ingestion of the 5-in-1 ration. Analysis of Table III. 93 reveals that only subject 7 failed to pass stools positive for occult blood during the recovery periods. The other subjects behaved similarly to the average subject. Why subject 7 did not pass positive stools is not clear. His food intake did not differ appreciably from that of the other men.

The next question raised was: Does the experimental diet have any influence on the occurrence of the reaction in the stools of the recovery period? That these diets did was suggested in the fact that only 79% of the recovery stools were positive -- and there relatively fewer strong reactions --- while 95% of the pre-period stools and 100% of the N 3000 stools were positive. An analysis of relevant data is presented in Table III. 94. The most striking finding brought out is that the meat bar and cereal biscuit combination (15/52/33) was never followed by a reaction of greater than +1. In the case of all other regimens, +2 and +3 reactions were observed. Since during recovery from the meat bar regimen one +3 stool was observed, the hypothesis may be made that the cereal biscuit contributed some substance which interfered with the development of the strongly positive reactions typical of the pre-period and positive control.

The next problem was to find out if any particular component or group of components of the 5-in-1 ration caused a strongly positive reaction. Two healthy males volunteered to serve as subjects. Every

TABLE III. 93

INDIVIDUAL VARIABILITY IN FECAL BENZIDINE REACTIONS DURING PERIODS OF 5-IN-1 INGESTION

Subject	5-in-1 Period	Stools Tested No.	Intensity of Benzidine Reaction 0	str	tr	+1	+2	+3	+4	% Positive
1	Pre.	3	0	0	0	0	1	1	1	100
	N 3000	2	0	0	0	0	1	1	0	100
	Recovery	4	0	0	2	0	2	0	0	100
2	Pre.	6	1	0	1	1	2	1	0	83
	N 3000	2	0	0	0	2	0	0	0	100
	Recovery	4	0	1	3	0	0	0	0	100
3	Pre.	6	0	0	1	3	2	0	0	100
	N 3000	2	0	0	0	1	1	0	0	100
	Recovery	6	1	1	2	1	0	1	0	83
4	Pre.	2	0	0	1	0	0	1	0	100
	Recovery	1	0	0	0	1	0	0	0	100
5	Pre.	3	0	0	0	1	1	1	0	100
	N 3000	2	0	0	0	0	0	2	0	100
	Recovery	5	0	0	1	2	1	1	0	100
6	Pre.	5	1	0	0	1	2	1	0	80
	N 3000	2	0	0	0	0	2	0	0	100
	Recovery	6	1	0	3	1	1	0	0	83
7	Pre.	6	0	1	3	1	0	1	0	100
	N 3000	2	0	0	2	0	0	0	0	100
	Recovery	5	5	0	0	0	0	0	0	0
8	Pre.	6	0	0	0	2	3	1	0	100
	N 3000	2	0	0	0	0	0	2	0	100
	Recovery	6	1	0	1	0	2	2	0	83
12	Pre.	4	0	0	0	0	3	1	0	100
	N 3000	2	0	0	0	0	0	2	0	100
	Recovery	6	1	0	0	0	2	3	0	83

stool passed was collected in a paraffin lined container and analyzed within 24 hr. Two markers (carmine or canned corn) were used both of which were shown not to react with benzidine dihydrochloride. Every change in experimental diet was separated by a period in which foods known not to cause a positive reaction were eaten. These control periods lasted until the stools had become negative. The data collected have been summarized in Table III. 95.

STAT
STAT

TABLE III. 94

RELATIONSHIP BETWEEN PRECEDING DIET AND FECAL BENZIDINE REACTION DURING SUBSEQUENT RECOVERY

Ration	Recovery Benzidine Reactions
5-in-1	0, tr, 1+, 2+, 2+, 2+, 3+
Fasting	0, 0, 0, 0, str, tr, tr, tr, 1+, 2+, 3+, 3+
Sugars*	0, tr, tr, 2+, 2+, 2+, 3+
Meat Bar	0, str, 3+
Chocolate Bar	0, 0, tr, 3+, 3+
Meat Bar and Cereal Biscuit	tr, tr, tr, tr, tr, 1+, 1+, 1+

*Jelly bar, spice drops, hard candy.

TABLE III. 95

BENZIDINE REACTIONS OF STOOLS FROM TWO SUBJECTS ON VARIOUS MEAT DIETS

Dietary Regimen	Subject	Experimental Day 1	2	3	4	Remarks
Usual Diet	F.S.	0	0	0	+	
	A.A.P.	0	0	0	tr	
Red-Meat Free I	F.S.	0	0	0	0	No beef, ham, veal
	A.A.P.	0	0	0	0	
Red-Meat Free II	F.S.	0	0	+	+	No beef, ham, veal
	A.A.P.	0	+	+	+	
Pork Products I (5-in-1)	F.S.	0	tr	tr	+	Ham, sausage, pork and gravy
	A.A.P.	0	0	+	+	
Pork Products II (5-in-1)	F.S.		0	0	+	Ham, sausage, pork and gravy
	A.A.P.		0	0	+	
Fresh Beef Products	F.S.	tr	2+	4+	1	Hamburger, roast beef, pot roast
	A.A.P.	4+	3+	tr	1	
Canned Beef Products (Commercial)	F.S.	3+	3+	2+	+	Hamburger, roast beef, roast beef hash, beef stew
	A.A.P.		tr	0	+	
Beef Products I (5-in-1)	F.S.	4+	4+	+	+	Hamburger, beef and gravy, roast beef
	A.A.P.	4+	4+	+	+	
Beef Products II (5-in-1)	F.S.	4+	4+	4+	+	Hamburger, beef and gravy, roast beef
	A.A.P.	4+	4+	+	+	

Five significant observations stand out. (1) When the subjects were on their usual diets or red meat-free diets (no beef, ham or veal) positive reactions greater than trace (tr) were never observed. (2) With the exception of two +1 reactions on day 1; subsistence on pork products of the 5-in-1 ration gave results comparable to the control. (3) When the subjects ate fresh commercial beef products the intensity of the reaction increased but only slowly reached a maximum and the maximum was not sustained. (4) A similar result followed subsistence on canned commercial beef products. One subject hardly reacted. (5) In two trials with 5-in-1 beef products, the reactions promptly became +4 and this intense reaction was sustained for as long as three days. The stools containing the markers were invariably +4 whereas, in the case of the fresh and canned commercial beef, the marked stools were never so strongly positive.

The conclusions which may be drawn from this experiment are: (1). A red meat-free diet as defined clinically is misleading. Pork products may be ingested without causing positive reactions. (2) Beef products cause strongly positive reactions. (3) The 5-in-1 beef products cause the most intense and sustained reactions. These ration components or their digested products probably were the basis for the observations reported in Table III. 92.

All ration components were directly tested with the routine benzidine reaction. Only those items containing meat gave positive reactions, the intensities being +3 to +4. This information, however, is inconclusive as implicating the components causing the fecal reaction.

Comment: The benzidine dihydrochloride reaction is generally accepted as the most sensitive and most specific test for blood (Hall, 1952; Mendeloff, 1953). False positive reactions may occur with the ingestion of beef in large amounts (Mendeloff, 1953). As little ingested blood as 30 ml may give positive reactions (Mendeloff, 1953). Ferrous iron does not react with this reagent either when ingested, or when tested directly in vitro. A method of eliminating the possibility of false positive reactions is to extract the stool with glacial acetic acid and boil the clear supernatant. Boiling destroys the organic peroxidases (Andrews and Oliver-Gonzales, 1942). We followed in principle the procedure recommended by Andrews and Oliver-Gonzales (1942) in testing several stools which gave strongly positive reactions. No significant change was observed in the intensity of the reaction before and after boiling a glacial acetic acid extract. Therefore, the presence of organic peroxidases can be ruled out. From our data one can conclude, at least tentatively, that the 5-in-1 ration does not cause bleeding in the gastrointestinal tract. An inorganic substance, other than a ferrous iron salt, which has peroxidase-like activity is strongly implicated. Perriclon was eliminated by in vitro tests. We suspect that some substance added as a preservative to the beef components of the 5-in-1 ration is the most

STAT

likely material causing this intensely positive reaction: Further investigations along these lines obviously would be desirable.

Clinical Observations. Some degree of gastrointestinal complaint was present during practically every phase and period of this study. The 5-in-1 ration, especially early in the study, caused what might be referred to as "burning anus." Physical examination never revealed any abnormal changes in the anal region. This complaint almost ceased being made about midway through the study, presumably either because the men became used to the condition or it actually disappeared. Certainly it was not sufficiently severe to evoke spontaneous complaint.

Various degrees of such complaints as hunger, hunger pangs, anorexia, nausea, emesis, abdominal cramps, abdominal pain, loose stools, and diarrhea occurred during many of the experimental periods. A synopsis of the frequency of all these symptoms is given in Table IV. 3. The only significant anal sign was the development of hemorrhoids in two of the subjects: Subject 2 during recovery from ST 0 and Subject 1 during the first week of 30/0/70 2000.

Two subjects developed episodes of severe diarrhea which required considerable symptomatic treatment: Subject 2 during the second week of starvation and again during the second week of 30/0/70 2000 and Subject 7 immediately after coming off 0/100/0 1000. The latter passed some 30 watery stools in a 24-hour period but responded rapidly to kaopectinate. Other subjects complained of diarrhea but generally questioning revealed that the actual condition was either a looser than normal stool or the watery postprandial stool stimulated by the gastro-colic reflex. These episodes have been recorded in the Case Histories (Appendix IV).

The regularity of bowel movements was markedly altered by the experimental diets. Frequently subjects went for seven to ten days without a defecation. Carmine markers and repeated questioning of the subjects made it possible to date accurately the stools and thus calculate the fecal output of the several substances measured. Since only a few of the subjects kept detailed records of daily defecations, it was not considered worth while to present anything more than impressions on this point.

Recovery from the experimental diets was a period of frequent acute gastrointestinal complaints. Indigestion ("heart burn", "acid indigestion", abdominal cramps, nausea, and vomiting) was a regular event. The intensity depended upon the manner in which the eating of a full diet was commenced. If the subject ate large meals of foods especially craved, the symptoms were intense. Such indiscretions as eating one can of fruit cup or one can of peanuts at a sitting caused considerable discomfort. One subject who developed severe indigestion had eaten almost 1000 Calories in ice cream,

oleomargarine, and peanuts at an evening snack. Another gained 12 pounds in eight hours: he had eaten seven pounds of food and drunk five pounds of water. On the other hand, frequent small meals or gradual increase of volume of the three daily meals caused little or no trouble. With experience the subjects learned how to eat during the early stages of recovery; the complaints became less severe. However, regardless of training and experience, some degree of indigestion was always experienced during the first three to four days. The subjects had what they called the "post-period blues," chiefly indigestion and depression. This syndrome was so characteristic that they soon accepted it as inevitable. One subject even preferred the experimental ration to the syndrome and remained on the wheat bar and cereal biscuit plus a few 5-in-1 supplements until he had completed a critical final examination. This experience indicates that rehabilitation is a critical stage of the process of rescue and return of the castaway to active duty. It deserves comprehensive study.

4. Function of Endocrine Glands

Analysis of all the data from the endocrinological point of view is exceedingly difficult, not so much because the data are less exhaustive or consistent than desired, but chiefly because endocrinological interrelationships are so complex that, at best, they are only imperfectly understood. Every cell in the body is regulated in some manner by hormones and when some bodily function deviates from normal it is wise to study the endocrinological associations.

When the whole body or part of it is subjected to injury or stress, this initiates a whole pattern of events which Selye (1946) has described under the terms "alarm reaction" and "general adaptation syndrome". Briefly stated, stress via the nervous system and adrenal medulla stimulates the anterior pituitary to secrete ACTH which, in turn, stimulates the adrenal cortex to secrete corticoids. The corticoids to a large extent, serve to maintain homeostasis and counteract the deleterious effects of stress. If the stress is severe and prolonged, exhaustion of the endocrines as well as the whole body occurs. In this study the diets that are deficient in calories, or are unpalatable, or cause metabolic derangements due to lack of proper balance of foodstuffs, act as stressing agents and one can look for evidences of altered adrenocortical activity as one of the first functional reactions of the body to these diets. In other words, one can assess the value or damage of each dietary regimen in terms of adrenocortical activity, among other bodily functions. The other endocrine organs must also be considered: thyroid, anterior and posterior pituitary, adrenal medulla, pancreas, and parathyroids in so far as this is possible. Gonadal function is not measured directly, although some indirect effects may be noted -- beard growth, nitrogen retention, and to some extent by 17 ketosteroid (17-KS) levels.

STAT

Adrenocortical Function. Evidence for functional changes in the cortex of the adrenal gland were sought in the following biochemical measurements: urinary output of 17-ketosteroids (17-KS), serum concentration of Na, K, and Cl, and mineral balances (Na, K, and Cl). The balances have been discussed in detail above.

Urinary excretion of 17-ketosteroids: The control data for each subject are listed in Table III. 96. The alterations (expressed as percent of pre-period average and as mg/24 hr) of the 17-KS output during the several experimental regimens are summarized in Figures III. 35, 36, and 37. The detailed data are tabulated in Appendix II.

TABLE III. 96

PRE-PERIOD DATA FOR URINARY 17-KETOSTEROID EXCRETION

Subject No.	17-Ketosteroid, mg/24 hr M	σ	C.V. %
1	11.6	1.1	9.6
2	9.7	1.4	14.4
3	16.8	1.9	11.0
4	21.4	---	----
5	10.7	1.2	11.0
6	19.8	0.9	4.6
7	15.3	0.8	5.4
8	24.3	2.4	9.8
12	27.0	2.4	8.8

The 17-ketosteroid level in the urine is an expression of the difference between the amount of adrenocortical secretion of hormones and tissue utilization of those same hormones. If the adrenal cortex is stimulated by an injection of ACTH and the bodily needs for corticoids remain the same, the 17-KS level in the urine will be increased. During mild stress there may be a temporary increase in 17-KS. However, when the tissue utilization of corticoids (as described by Sayers, 1950) increase over the adrenocortical output of those hormones, the 17-KS level in the urine is decreased. The low levels of 17-KS during starvation or low calorie diets indicate that the adrenal cortex cannot keep up with the needs of the tissues; either because its activity is decreased or, more likely, because the requirements of the body for homeostatic maintenance are disproportionately increased over adrenocortical secretion. In this study only the 17-KS levels are known and these can be considered as

CAPTION FOR FIGURES III. 35 and III. 36

17-KETOSTEROID: 7-DAY POOL VS: 2-3 DAY POOL SUBJECTS 7 AND 8.

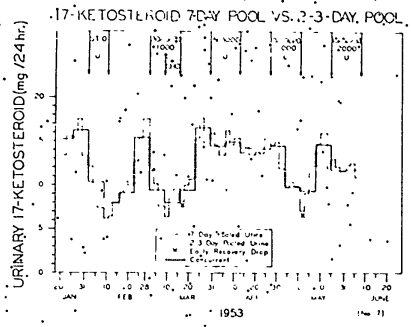

FIGURE III. 35

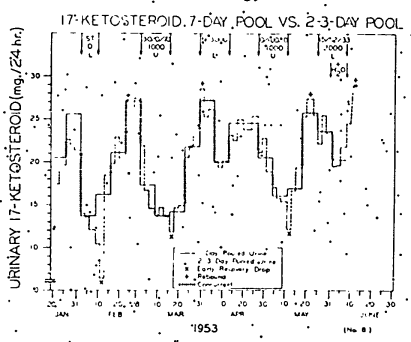

FIGURE III. 36

STAT
STAT

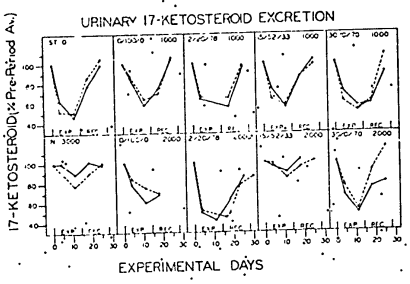

FIGURE III. 37. URINARY 17-KETOSTEROID EXCRETION.

Urinary 17-Ketosteroid Excretion (Percent Pre-Period Average) in Relation to Consumption of Different Experimental Nutrient Mixtures. Data Calculated from 7-Day Pooled Urines. Values Have Been Plotted at Mid-Point of the Seven-Day Periods. Continuous Line, Unlimited Water; Dashed Line, Limited Water; Double Dashed Line, Limited Water Plus CHO.

a good index of the degree of stress of any dietary regimen. If the dietary regimen causes a sharp drop in 17-KS, it is considered to be a greater cause of stress than one causing a moderate drop. The greatest decrease in 17-KS is indicative of the greatest stress. If recovery is slow following the dietary regimen, then that regimen is considered to be more of a stress than an other which is associated with rapid recovery.

The longer the dietary stress is maintained, the lower the levels of 17-KS. Thus it would not be unexpected for the second week of any dietary regimen to be accompanied by lower 17-KS levels. Where this is not true there may have been adaptation to a diet which at first was injurious to some extent.

Analysis of each daily urine sample for each man would give

most information but under the circumstances of this investigation, such a procedure was not feasible. However, the urinary 17-KS levels of two men, subjects 7 and 8, were determined three times per week (2- and 3-day pools). The relationship of the 2- and 3-day pools of urine with the weekly pools is illustrated in Figures III. 35 and 36. On the whole the agreement is quite good so it can be assumed that the same correlations undoubtedly would exist for the other subjects. The mean for all seventeen 2-3-day pools of the pre-periods for subject 8 is 23.5 mg/24 hours as compared to 24.3 mg/24 hours for the six weekly pre-periods. For subject 7, seventeen 2-3-day pools averaged 14.8 mg/24 hours as compared to 15.3 mg/24 hours based on six weekly pre-period pools. One can thus conclude that the weekly pools do reveal the significant major changes in 17-KS levels. As would be expected the 2- and 3-day pools bring out fluctuations and greater, though more gradual, changes than the weekly urine pools. In addition it becomes evident that the 17-KS continue to drop during rehabilitation following the experimental diet. Following each dietary regimen except for positive control (and 2000 Cal/man/day of meat bar-cereal biscuit, which was not followed by a 2-day recovery pool), there was a marked decrease of 17-KS in the first 2-day urine pool of the recovery period (post period) for both subjects 7 and 8. Subject 7 was given 1000 Cal of CHO to supplement the 1000 Cal of meat bar after one week on the latter diet. In the first 2-day pool the 17-KS continued to fall. This continual decrease during recovery indicates that there is a lag of two days (or it may be found to be one day if daily urine analyses are made) during recovery. It may be that with greater intake of food there is greater total metabolism, which would mean greater rate of tissue utilization of corticoids than rate of increase of adrenocortical activity, with the result that the 17-KS level falls. Subject 8 shows a higher than normal rebound following each of the experimental diets except positive control. This evidently reflects overcompensation of the adrenals to the previous stress. Subject 7 shows these same peaks but to a lesser degree.

The data on the 17-KS are illustrated in Figure III. 37. In preparing this figure, the 17-KS levels for each subject during each pre-period were averaged (Table III. 96). This value was assigned the value of 100. The 17-KS levels for the experimental and rehabilitation periods were calculated as a percentage of this control value.

Negative control. In all subjects the 17-KS level dropped precipitously during starvation. The drop after one week of starvation ranged from a low of 44% to the highest value of 68% of control. Only one subject (No. 2) endured 14 days of total starvation, and for some unexplainable reason his 17-KS level increased from 53% during the first week to 60% of normal during the second. All others who continued on the starvation regimen showed a continued decrease during the second week. Unfortunately, in Group II

the urines of the starvation regimen and of rehabilitation during the second week were pooled. In one case (subject 7) there was a decrease and in another (subject 8) an increase. Rehabilitation of one or two weeks (recovery period plus the time each went off the starvation regimen during the second week) was associated with a rise of 17-KS levels to near-normal (94-96%) in only two subjects (1 and 12). Apparently the rate of recovery was more variable than the rate of response to stress. Perhaps subject 2 made some adaptation during the second week of starvation in so far as the corticoid to tissue utilization ratio was concerned. The actual levels were very low (5.1 and 5.8 mg/24 hours), at the Addisonian level (Bodansky and Bodansky, 1952).

Positive control (3000 Cal/man/day): The results are variable, but for the most part lie within 20% of normal (Figure III. 37). Two subjects (2 and 8) had levels slightly above normal for the first week, fell to below normal after the second week and then rebounded to normal in the recovery period. The 17-KS in the urine of two subjects on limited water fell to low levels: subject 1 to 50% at the end of the second week and subject 3 to 69% at the end of the first week. Subject 3 went off the diet during the recovery period and, judging from the 17-KS level during the subsequent control period, his vacation was exhausting. Since the other two subjects (Nos. 6 and 8), on limited water, excreted 17-KS in the same range as the other subjects, it suggests that limited water per se did not produce marked stress.

1000 Cal/man/day regimens: The 17-KS levels for all subjects on 1000 Cal/man/day uniformly fell to very low levels, but the pattern for each diet was different (Figure III. 37). Unfortunately, the evidence for normal mixture (meat bar plus cereal biscuit) produced two different patterns in the two pairs who were subsisted on it. Subjects 5 and 6 exhibited only a slight drop during the first week, a sharp drop during the second and a complete return to normal one week afterwards. Subjects 1 and 2, on the other hand, manifested a great drop (53% and 41% of normal, respectively) during the first week, a slight rise during the second and during a week of rehabilitation recovered only to 72% and 66% of normal, respectively. Thus, for subjects 5 and 6 this diet produced the least change from normal (at the 1000 Cal/man/day regimens). The high carbohydrate (0/100/0) produced only a small drop during the first week and a greater one during the second week. Subjects 5 and 6 showed fair recovery but not subjects 7 and 8. The meat bar (30/0/70) caused a sharp drop during the first week, a continued drop during the second, and recovery only to the level of the first week or less after one week of rehabilitation. The drop produced by the 2/20/78 regimen during the first week was like that for meat bar. Unfortunately, the samples collected during the second week could not be analyzed, but recovery was incomplete after one week as in the case of meat bar.

2000 Cal/man/day regimens: This caloric level produced less

decrease of the 17-KS levels than did the 1000 Calorie diets (Figure III, 37). Again meat bar and cereal biscuit (15/52/33) produced the least change. Before he withdrew from the study, this regimen was the only one for subject 4 and he was the only one whose 17-KS levels increased during an experimental (1000-Cal or 2000-Cal level) diet. It may be that the two pre-period urinary specimens were not enough to establish reliable control levels for him. Even though the high carbohydrate regimen (0/100/0) produced less change than did either the 2/20/78 regimen or the meat bar regimen (30/0/70), recovery was slow. Recovery after meat bar was quite good (74 and 91% of normal). The 2/20/78 regimen produced the greatest drop (42% of control) and the least recovery (63% of control).

Limited water: It is difficult to generalize concerning the effect of limited water (600 ml/man/day) because the data are not all consistent with regard to 17-KS levels during the various dietary regimens. During starvation evidently the amount of water consumed was of little consequence. On positive control (N 3000), however, only one subject (No. 6) showed no effect, and subject 8 fell slightly during the second week. Subject 3 dropped rapidly the first week, but, since he abandoned the diet in the recovery period, one cannot be sure that this drop was associated chiefly with limited water. Subject 1 had a drop in 17-KS to 50% of control during the second week of positive control. It is difficult to attribute this decline to the diet but perhaps it is an effect of limited water with large (3000 Cal/man/day) food intake.

Meat bar was difficult for subject 7 at the 1000-Calorie level and limited water, but at the 2000-Calorie level subject 1, who was on limited water and meat bar, fared as well as, or even better than, subject 2 who could drink water ad lib. One could expect a high protein diet to be most difficult for a person on limited water, but, as seen above, this is not always the case. Perhaps if the subjects were exposed to climatic extremes, the effects of limited water would be reflected in the 17-KS levels. Other criteria will have to be used to get a more sensitive index of the effects of limited water on each subject.

These 17-KS data are in agreement with those obtained by Miller et al. (1948) and Lundan et al. (1948) in so far as the drop in 17-KS during fasting is concerned. Lundan et al. noted that if a diet were deficient in nitrogen, but otherwise adequate, no drop in 17-KS occurred despite the fact that the negative nitrogen balance was close to the fasting level. Our studies indicate that during low-calorie diets the small amount of nitrogen in the meat bar-cereal biscuit diet may have been beneficial when compared to the effects of very low protein diets (0/100/0 and 2/20/78) on 17-KS levels.

To summarize from the purely endocrinological point of view,

STAT

several conclusions can be drawn: (1) the greater the caloric intake, the less the drop in the urinary 17-KS level; (2) with luxus supplies of water the decline in 17-KS tended to be reduced; (3) if a choice between nutrient mixtures were to be made on these grounds alone, we would rank the regimens in the following order 15/52/33 (small decrease and rapid recovery), 0/100/0, 30/0/70, and 2/20/78.

Serum electrolytes--sodium potassium and chloride: The pre-period data for fasting serum sodium, potassium, and chloride are summarized in Table III. 97. The values are all normal as judged by the generally accepted standards. The alterations in these electrolytes observed during the several experimental regimens have been presented in Tables III. 98, 99, and 100. No striking trends were detected in any of these electrolytes in spite of the fact that drastic variations took place in the intakes of sodium, potassium, and chloride.

These findings clearly demonstrate the exacting homeostatic regulation of serum sodium, potassium, and chloride. Furthermore, the implication is that none of the dietary regimens evoked any serious alteration in adrenocortical function. To be sure, adrenocortical function was taxed by subsistence on the several nutrient combinations --- the wide variations in 17-KS provide this evidence. Functional breakdown, however, did not take place. Hypofunction of salt-retaining mechanism of the adrenal cortex might be expected to depress the serum sodium and elevate the serum potassium (Bodansky and Bodansky, 1952). No changes were evident.

Thyroid Function. Metabolic rate: The metabolic rate is adjusted to the needs of the body in healthy individuals. It increases in exercise and decreases during sleep. The exact mechanisms involved are not known, except for the fact that the thyroid, anterior pituitary, and adrenal cortex are involved. A popular theory holds that, as in the case of the pituitary-adrenal axis, the anterior pituitary (perhaps via the hypothalamus) responds to low levels of thyroid hormone in the blood by secreting thyrotropin, which in turn stimulates the thyroid to release more thyroid hormone into the blood stream. In order for the thyroid hormone to be effective, the body must have corticoids available. Evidently tissue utilization of thyroid hormone results in its disappearance (destruction) from the blood. Nervous stimulation of muscular activity leads to increased metabolism as long as thyroid and adrenocortical hormones are available. With reduced food intake there is reduced metabolic rate and hence reduced depletion of body stores of foodstuffs. The reduced metabolism in this sense is an aid to survival as long as the survivor can meet emergencies by rapid mobilization and utilization of energy.

Resting metabolism, rather than basal metabolic rate, was used in this study because it was easier to measure and hence could be

TABLE III. 97

PRE-PERIOD DATA FOR SERUM ELECTROLYTES

Subject	Na, mEq/l. M	σ	C.V.	K, mEq/l. M	σ	C.V.	Ca, mg/100 ml M.	σ	C.V.	Cl, mEq/l. M	σ	C.V.	PO_4, mg/100 ml M	σ	C.V.
			%			%			%			%			%
1	143	4	2.8	4.6	0.4	8.9	10.7	0.2	1.9	101	2	1.9	4.50	0.53	11.8
2	144	3	2.4	4.9	0.3	6.7	10.3	0.4	3.9	100	2	1.6	4.12	0.20	4.8
3	145	3	2.0	4.5	0.5	11.0	10.6	0.5	4.7	103	2	2.3	4.18	0.31	7.4
4	144	-	---	4.8	---	---	10.4	---	---	95	-	---	----	----	---
5	142	3	2.2	4.2	0.2	3.6	10.4	0.8	7.7	104	3	2.7	4.54	0.06	1.3
6	144	3	2.3	4.3	0.3	6.3	10.2	0.7	6.9	101	3	3.5	4.24	0.43	10.1
7	142	4	2.8	4.2	0.3	6.6	9.7	0.5	5.2	103	4	3.4	4.42	0.33	7.5
8	143	4	2.6	4.2	0.2	5.7	10.5	0.7	6.7	103	3	3.2	4.45	0.29	6.4
12	143	3	2.0	4.4	0.2	5.4	10.3	0.2	1.9	103	2	1.6	4.48	0.06	1.3

TABLE III. 98

SERUM SODIUM IN RELATION TO EXPERIMENTAL REGIMEN
(Mean and Range, mEq/l)

Nutrient Mixture	Pre-Period	Experimental I	II	Recovery
N 3000	142	144	142	142
	137-145	140-152	137-146	135-154
ST 0	146	143	147	146
	145-147	140-145	143-149	144-149
0/100/0	141	147	143	145
1000	137-145	143-159	143	141-150
0/100/0	142	150	145	148
2000	---	144-156	142-146	145-150
2/20/78	138	137	138	140
1000	137-140	137	137-140	137-144
2/20/78	142	144	142	151
2000	140-143	141-143	141-143	150-152
15/52/33	138	144	142	146
1000	135-140	140-147	137-146	142-152
15/52/33	146	146	146	146
2000	144-151	143-152	141-149	144-147
30/0/70	144	143	142	142
1000	143-145	143	141-143	141-144
30/0/70	142	140	136	138
2000	141-144	140-141	125-137	137-140

used in field studies, whereas the BMR would not be feasible there. In preparation for the determination of the resting metabolic rate, the subject reclined in a horizontal position for 30 minutes. To further insure standard conditions as much as possible, the measurement was made at the same hour on the same day of each week. Since there was no control of previous activity, this might have had a considerable effect, especially if sleep had immediately preceded the test for a couple hours. This is the explanation offered for some of the low rates for subject 2 and for the very low rate during one pre-period for subject 8.

The mean pre-period values for resting metabolic rate have been summarized in Table III. 101. The observed alterations in the resting metabolic rate (expressed as a percent of the pre-period mean) have been illustrated in Figure III. 38.

Positive and negative control: All the subjects showed decreased resting metabolism during starvation, except for subject 8, whose metabolism was above normal the first week before dropping to 83% of normal on the 10th day. There was a rebound of every subject to above normal levels during the recovery period. Positive control (3000 Cal/day) altered the resting metabolic rate only slightly and

TABLE III. 99

SERUM POTASSIUM IN RELATION TO EXPERIMENTAL REGIMEN
(Mean and Range, mEq/l)

Nutrient Mixture	Pre-Period	Experimental I	II	Recovery
N 3000	4.6	4.3	4.5	4.4
	4.2-5.3	4.2-4.6	3.8-5.3	3.8-5.0
ST 0	4.4	4.9	5.0	4.5
	4.1-4.6	4.6-5.5	4.4-5.3	4.1-4.6
0/100/0	4.1	4.3	3.9	4.5
1000	3.6-4.5	4.1-4.9	3.0-4.4	4.2-4.7
0/100/0	3.7	4.3	4.1	5.3
2000	---	4.1-5.0	3.8-4.5	4.1-5.8
2/20/78	4.4	4.4	4.1	3.9
1000	4.4	4.4	3.8-4.4	3.8-4.0
2/20/78	4.0	3.8	3.8	4.7
2000	4.0	3.8	3.8	4.6-4.8
15/52/33	4.2	4.2	4.4	4.4
1000	3.8-4.6	3.8-4.5	4.2-4.5	4.2-4.6
15/52/33	4.6	4.2	4.5	4.5
2000	4.1-5.2	4.1-4.2	4.3-4.6	4.4-4.6
30/0/70	4.5	4.5	4.4	4.4
1000	4.5	4.1-4.6	4.4	4.4
30/0/70	4.4	4.5	4.4	4.4
2000	4.1-4.6	4.4-4.6	4.4	

was followed by a rebound to slightly above normal. The low 17-KS levels for subjects 1 and 3 on positive control were not correlated with resting metabolic rates, although subject 1 had a low metabolic rate the first week. The lowest 17-KS level was in the second week.

1000 Cal/man/day: The diets containing the most protein (15/52/33 and 30/0/70), as would be expected, prevented the metabolism from dropping to the same extent as it did on the carbohydrate (0/100/0) and low carbohydrate-high fat (2/20/78) diet.

2000 Cal/man/day: As would be expected, there was less decrease of metabolism on the 2000 Cal/man/day dietary regimens than on the 1000 Cal/man/day diets.

Limited water: As far as resting metabolism is concerned, there was no effect produced by limited water.

Urinary creatine: The control data for urinary creatine have been presented in Table III. 102. According to the generally accepted point of view (Sodansky and Sodansky, 1952) little or no creatine is excreted by the normal adult male. This matter, however, is controversial for some investigators claim that as much as

STAT

TABLE III. 100

SERUM CHLORIDE IN RELATION TO EXPERIMENTAL REGIMEN
(Mean and Range, mEq/l)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
M 3000	103	105	103	104
	98-106	102-109	100-108	102-106
ST 0	99	---	103	105
	95-102		96-113	100-110
0/100/0	105	100	105	103
1000	103-107	99-101	97-115	102-104
0/100/0	103	---	100	---
2000	100-106		96-104	
2/20/78	104	104	104	
1000	102-106	104	102-106	
2/20/78	104	---	103	---
2000	102-105		102-104	
15/52/33	102	---	104	---
1000	101-103		102-106	
15/52/33	99	104	101	---
2000	95-101	100-108	100-102	
30/0/70	108	107	102	102
1000	107-108	105-109	98-107	100-103
30/0/70	102	98	99	98
2000	100-103	95-100	94-104	98

TABLE III. 101

PRE-PERIOD DATA FOR RESTING METABOLISM

Subject No.	Resting Metabolism, Cal/day M	σ	C.V. %
1	1896	129	6.8
2	2065	224	10.9
3	2139	226	10.6
4	2008	---	----
5	2154	129	6.3
6	2051	171	7.5
7	2283	161	7.5
8	2153	69	3.4
12	2000	159	7.4

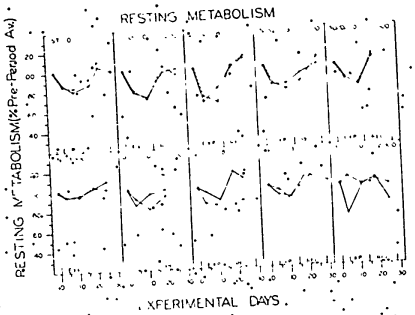

FIGURE III. 38. RESTING METABOLISM.

Continuous Line, Unlimited Water; Dashed Line, Limited Water.

TABLE III. 102

PRE-PERIOD DATA FOR URINARY CREATINE
gm/24 hr

Subject No.	Creatine, gm/24 hr M	σ	C.V. %
1	0.45	0.21	47
2	0.40	0.18	45
3	0.51	0.30	59
4	0.64	----	--
5	0.38	0.07	18
6	0.36	0.04	11
7	0.34	0.14	41
8	0.38	0.11	29
12	0.44	0.19	43

STAT
STAT

.2 gm may be found in urine from normal adult males. We uniformly and creatine and the relative variability was very large. Coefficients of variation ranged from 11 to 59%. Critical recovery studies will have to be done to confirm these findings.

The variations of urinary creatine during the several experimental regimens are tabulated in Table III. 103. If one adopts the position that creatinuria is in part regulated by the activity

TABLE III. 103

URINARY CREATINE IN RELATION TO EXPERIMENTAL REGIMEN
(Mean and Range, gm/24 hr)

Nutrient Mixture	Pre-Period	Experimental I	II	Recovery
M 3000	0.45	0.36	0.17	0.34
	0.18-0.75	0.17-0.58	0.12-0.30	0.19-0.68
ST 0	0.45	0.24	0.25	0.41
	0.30-0.77	0.12-0.44	0.12-0.45	0.12-0.70
0/100/0	0.37	0.22	0.14	0.56
1000	0.31-0.45	0.17-0.27	0.12-0.15	0.20-0.78
0/100/0	0.26	0.19	0.23	0.24
2000	0.20-0.38	0.08-0.46	0.12-0.30	0.10-0.38
2/20/78	0.44	0.38	0.15	0.11
1000	0.42-0.46	0.30-0.45	0.12-0.18	0.10-0.12
2/20/78	0.14	0.12	0.24	0.32
2000	0.12-0.16	----	0.14-0.33	0.26-0.38
15/52/33	0.29	0.12	0.27	0.46
1000	0.10-0.39	----	0.14-0.47	0.22-0.68
15/52/33	0.53	0.36	0.21	0.41
2000	0.13-0.78	0.24-0.42	0.13-0.28	0.27-0.53
30/0/70	0.48	0.30	0.60	0.41
1000	0.39-0.56	0.29-0.31	----	0.20-0.56
30/0/70	0.34	0.44	0.22	0.28
2000	0.20-0.45	0.43-0.46	0.16-0.28	0.26-0.30

of the thyroid gland (Bodansky and Bodansky, 1952), our data tend to support the view that these diets may have caused a reduced activity of the thyroid gland. There was a decreased output of creatine, especially on those regimens which caused reduction of the resting metabolic rate. Because of the large variability in the quantity of this substance excreted per day, confirmation of these trends must await additional data, particularly wherein the environmental stresses are greater than those experienced in the present study.

Pancreatic Function. Blood sugar: Regulation of the blood glucose level involves a multiplicity of factors, such as the amounts and kinds of food ingested and absorbed, the pancreas (insulin), the adrenal medulla (epinephrine), the adrenal cortex

(glucocorticoids), the thyroid (thyroid-hormone stimulation of metabolic rate), the anterior pituitary (somatotropin), and other diverse factors such as the nervous system, intermediary metabolism, and even sex hormones. Since blood glucose levels vary greatly during the day, in order to standardize conditions as much as possible, the blood for the determination was taken on the same day of the week following a period of 14-16 hours of fasting. The pre-period means for fasting blood sugar are given in Table III. 104. The variations in blood glucose occurring during the several experimental regimens are illustrated in Figure III. 39. The detailed data may be found in Appendix II.

TABLE III. 104

PRE-PERIOD DATA FOR WHOLE BLOOD GLUCOSE

Subject No.	Blood Glucose, mg/100 ml M	σ	C.V. %
1	80	5.1	6.4
2	66	4.1	6.2
3	92	9.3	10.1
4	87	---	----
5	75	6.8	9.1
6	76	6.0	7.9
7	74	7.5	10.0
8	77	9.3	1.2
12	71	2.7	12.1

Negative control: In all but two of the subjects starvation produced a decreased level of glucose in the blood, a change associated with low levels of metabolism at the same time. This alteration suggests there may have been relatively more circulating insulin than the substances that mobilize glucose, especially the corticoids. The low 17-KS levels suggest that the adrenocortical function did not keep pace with bodily needs. In the week or less following starvation the blood glucose of the 6 subjects with low blood glucose returned to normal and then was followed by a slight rise (overcompensation). The overcompensation may have been due to a greater proportion of corticoids compared to insulin levels and systemic needs. The 17-KS level in the urine rises to a high point at this time (Figures III. 35 and 36), which is highly indicative that such a situation existed.

Positive control, 3000 Cal/man/day: During positive control the blood glucose values remained at normal levels with less than 10% fluctuation from normal except in subjects 2 and 7. At the end of the positive control period subject 2 showed a 20% increase whereas subject 7 had a 21% decrease.

1000 Cal/man/day: When more than two subjects were used for

STAT
STAT

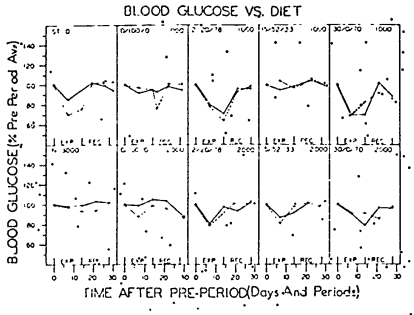

FIGURE III. 39. BLOOD GLUCOSE VS: DIET.

Continuous Line, Unlimited Water; Dashed Line, Limited Water; Double Dashed Line, Limited Water Plus CHO.

any one 1000 Cal/man/day diet, the general effects of each diet were clear cut. Meat bar and cereal biscuit (15/52/33) produced the least change from normal. As would be expected, with high carbohydrate (0/100/0) there was no marked drop in blood glucose. The 2/20/78 regimen caused a steady decrease followed by a sharp rise to normal in the recovery period. Meat bar (30/0/70) caused the sharpest drop in blood sugar, followed by good recovery in the first and a slight decrease during the second week.

2000 Cal/man/day: On the whole these diets produced less deviation from normal than did the 1000 Cal/man/day diets. The meat bar diet (30/0/70) had less effect on the blood-sugar level than the others which showed a drop the first week and return to normal or above during the second. One can conclude that the total caloric intake was of greater importance than the distribution of calories at the 2000 Cal/man/day level.

Limited water: Restriction of water had no effect on the blood-glucose level in so far as the results of this study are concerned.

Serum amylase and lipase: In the presence of severe pancreatic dysfunction the serum level of amylase and lipase may increase, (Bodansky and Bodansky, 1952). The pre-period means for serum amylase and lipase are summarized in Table III. 105. The variations noted during the experimental diets are presented in Tables III. 106 and 107. Except for the one subject who developed biliary dyskinesia while subsisting on 2/20/78 2000 L, there were no significant variations in serum amylase. This subject (No. 12) had a serum amylase of 188 units during this clinical episode. Subsequently on 0/100/0 2000 U the serum amylase rose to 343 units. Both values are above the limits of normal. Their clinical significance is discussed below.

TABLE III. 105

PRE-PERIOD DATA FOR BLOOD ENZYMES

Subject No.	Serum Amylases* M	σ	C.V. %	Serum Lipases** M	σ	C.V. %
1	71	24	34	22	8	37
2	99	12	13	20	8	40
3	69	17	25	22	10	47
4	--	--	--	8	--	--
5	81	14	18	14	4	31
6	77	13	16	28	20	71
7	59	17	28	16	8	47
8	90	7	8	14	7	53
12	122	26	22	12	4	29

*Amylase units/100 ml of serum
**ml of 0.05 N NaOH/100 ml of serum

No abnormal values for serum lipase were detected at any time.

Parathyroid function: The parathyroid glands are primarily responsible for the regulation of calcium and phosphorus metabolism. The serum levels of calcium and inorganic phosphate are usually considered as indicators of the functional state of these glands. In general, hyperfunction is indicated by an increase in serum calcium and a decrease in serum inorganic phosphate, the reverse is true in hypofunction (Bodansky and Bodansky, 1952). Low calcium diets, on the other hand, will also tend to lower the serum calcium whereas the effect of dietary phosphate on blood serum inorganic phosphate is not clear (Greenberg, 1947). The control data on serum calcium and serum inorganic phosphate have been summarized in Table III. 97. The changes in these substances during the several experimental regimens are presented in Tables III. 108 and 109.

STAT

TABLE III. 106

PANCREATIC FUNCTION: SERUM AMYLASE
(Mean and Range, amylase units/100 ml)

Nutrient Mixture	Pre-Period	Experimental I*	II	Recovery*
N 3000	79	--	85	--
	40-159	--	60-121	--
ST 0	81	--	74	--
	31-159	--	22-121	--
0/100/0	73	--	59	--
1000	60-96	--	41-90	--
0/100/0	90	--	136	--
2000	79-114	--	38-343	--
2/20/78	83	--	49	--
1000	76-90	--	46-52	--
2/20/78	102	--	124	--
2000	76-128	--	60-188	--
15/52/33	94	--	95	--
1000	90-96	--	68-106	--
15/52/33	86	--	76	--
2000	83-90	--	56-114	--
30/0/70	68	--	72	--
1000	53-83	--	68-76	--
30/0/70	79	--	71	--
2000	76-82	--	60-82	--

*No measurements were made in these periods.

The control values were all within the normal range. The same holds for most of the observations collected during the experimental regimens. The only nutrient combination associated with a clinically significant diminution in serum calcium was the 2/20/78 2000 regimen. Both subjects had low serum calcium values, the average being 8.7 mg/100 ml. There was a concurrent moderate increase in serum inorganic phosphate. This nutrient combination was the only calcium-free regimen which produced significant clinical deterioration in the subjects. The high carbohydrate diets and the high fat diet at 1000 Cal/day were not associated with a decreased serum calcium. Probably then the low serum calcium of the high fat diet at 2000 Cal/day was not caused by the low calcium intake. Fat impairs the absorption of calcium (Greenberg, 1947) but, since there was relatively little calcium in this diet to begin with (Table III. 28), it is doubtful that this mechanism contributed to the low serum calcium. Differences in urinary calcium and phosphorus likewise do not explain these findings (Tables III. 27 and 31). The serum findings then are consistent with hypofunction of the parathyroid glands but they are not sufficient to establish such a diagnosis conclusively. These observations should be extended by studies on other subjects

TABLE III. 107

PANCREATIC FUNCTION: SERUM LIPASE
(Mean and Range, ml 0.05N NaOH/100 ml)

Nutrient Mixture	Pre-Period	Experimental I*	II	Recovery*
N 3000	22	--	15	--
	10-55	--	10-26	--
ST 0	16	--	24	--
	5-35	--	5-50	--
0/100/0	20	--	20	--
1000	15-24	--	14-25	--
0/100/0	19	--	28	--
2000	13-35	--	14-45	--
2/20/78	10	--	20	--
1000	10	--	8-32	--
2/20/78	19	--	14	--
2000	18-20	--	12-16	--
15/52/33	28	--	22	--
1000	20-38	--	8-47	--
15/52/33	13	--	12	--
2000	4-26	--	8-20	--
30/0/70	--	--	12	--
1000	--	--	10-15	--
30/0/70	12	--	30	--
2000	10-15	--	30	--

*No measurements were made in these periods.

and on men exposed to environmental stress while subsisting on a high-fat regimen.

Clinical observations: There are only two pertinent clinical endocrinological observations. One subject complained of increased nocturnal emissions for several weeks beginning midway through the experiment. There was insufficient data, however, to attribute this phenomenon to any aspect of the experiment.

One subject (No. 2) who was fasted 14 days developed an episode of hypoglycemia on the first day of rehabilitation. The fasting blood sugar on the morning of the attack was 50 mg/100 ml. This episode supports the contention above that the starvation may have evoked a relative hyperinsulinism. In such a situation it is known (Conn, 1947) that ingestion of foods rich in carbohydrate may precipitate acute symptoms. In the discussion of carbohydrate intake it was pointed out that there was definite evidence of a craving for carbohydrate in the recovery period following starvation (Table III. 43). Subject No. 2 is known to have exhibited such a craving. It is reasonable to conclude then that we were dealing with an episode of spontaneous hypoglycemia such as described by

TABLE III. 108

PARATHYROID FUNCTION: SERUM CALCIUM
(Mean and Range, mg/100 ml)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	10.5	9.8	10.2	---
	9.5-11.3	9.7-10.0	9.3-11.0	
			9.9	11.8
ST O	10.6	---	9.3-10.4	11.1-12.3
	10.3-11.3		10.6	9.7
0/100/0	10.0	---	10.1-11.5	9.1-10.2
1000	9.0-11.2		10.7	---
0/100/0	10.4	---	10.0-11.2	
2000	9.6-10.8		11.0	---
2/20/78	9.8	---	10.7-11.2	
1000	9.8		8.7	---
2/20/78	10.7	---	8.6-8.8	
2000	10.6-10.8		10.6	---
15/52/33	10.0	---	10.2-11.1	
1000	9.4-10.6		10.3	---
15/52/33	11.0	---	9.7-10.6	
2000	10.4-11.9		10.2	---
30/0/70	9.3	---	10.2	
1000	9.6-10.0		9.8	---
30/0/70	10.3	9.9	9.8-9.9	
2000	10.2-10.4	9.6-10.2		

Conn (1947). The details of this episode are given in Appendix IV.

5. Respiratory Function

Respiratory function was measured in terms of pulmonary ventilation, oxygen consumption, carbon dioxide production, and respiratory quotient. Only the material for the resting condition will be presented in the present section, the results for exercise being reserved for the section on exercise stress.

Each subject was measured under standard conditions at the same time of day, a time that best suited his own schedule. Following the resting observations, a work-stress test was performed. (The present data are not the same as were presented above in the section on thyroid function.)

Pre-period data for pulmonary ventilation, oxygen consumption, and respiratory quotient are presented in Table III. 110 for each subject. A pulmonary ventilation of 5 - 9 liters per minute is normal for young men; our subjects showed but moderate variation from this mean. Our subjects were resting, but not basal; they were post-cibal, but not postabsorptive. Therefore, the oxygen consumption and respiratory quotient would be expected to be

TABLE III. 109

SERUM INORGANIC PHOSPHATE
(Mean and Range, mg/100 ml)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	4.36	---	4.03	4.55
	4.10-4.55		3.33-4.74	4.55
ST O	4.05	4.39	4.11	---
	3.50-4.50	4.30-4.55	3.65-5.0	
0/100/0	4.50	---	4.06	---
1000	4.0-4.80		3.80-4.40	
0/100/0	4.25	---	4.17	---
2000	4.10-4.55		3.65-4.75	
2/20/78	4.32	---	3.65	---
1000	4.10-4.55		4.65	
2/20/78	4.25	---	4.60-4.80	---
2000	3.95-4.55		4.18	
15/52/33	4.61	---	3.75-4.40	---
1000	4.30-4.80		3.50	
15/52/33	4.72	---	3.33-3.65	4.38
2000	4.65-4.80		4.65	4.25-4.50
30/0/70	4.34	---	4.65	---
1000	3.95-4.75		4.02	
30/0/70	4.00	---	3.50-4.50	---
2000	4.30-5.30			

TABLE III. 110

PRE-PERIOD DATA FOR RESTING RESPIRATORY FUNCTION:
PULMONARY VENTILATION (l/min), OXYGEN CONSUMPTION
(ml/min) AND RESPIRATORY QUOTIENT

Subject No.	Pulmonary Ventilation M	σ	C.V. %	Oxygen Consumption M	σ	C.V. %	ml/m²	Respiratory Quotient M	Range
1	5.46	0.63	11.6	273	46	16.8	150	0.80	0.72-0.88
2	6.91	1.39	20.1	309	38	12.3	168	0.91	0.80-0.98
3	7.26	0.69	9.5	308	35	11.4	153	0.88	0.82-0.96
4	9.43	----	----	289	--	----	143	1.02	0.91-1.13
5	5.98	0.47	8.0	295	19	6.4	164	0.84	0.78-0.89
6	6.69	1.23	18.2	329	24	7.3	188	0.95	0.79-1.09
7	6.68	0.55	8.2	310	23	7.4	165	0.85	0.82-0.94
8	6.59	1.21	18.4	275	31	11.3	148	0.91	0.84-0.97
12	6.89	0.73	10.6	310	24	7.7	156	0.87	0.78-0.92

somewhat higher than they would have been for the postabsorptive condition. However, both were consistent and showed a not unusual variation.

Data for the experimental periods are presented in Tables III. 111, III. 112 and III. 113. As compared with the pre-periods and recovery periods, there was a low pulmonary ventilation in all experimental periods. It was lowest in the 1000-Calorie regimens, and addition of Calories to the same nutrient combination raised the pulmonary ventilation. In starvation, presumably because of tissue breakdown, the pulmonary ventilation was higher than in any of the other restricted regimens.

TABLE III. 111

RESPIRATORY FUNCTION: RESTING PULMONARY VENTILATION
(Mean and Range, l/min)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	6.34	7.26	6.30	6.54
	4.35-7.61	5.24-9.86	4.76-7.92	6.01-8.58
ST 0	7.22	5.79	5.76	6.62
	4.58-9.49	4.58-7.03	3.98-7.34	4.95-8.06
0/100/0	6.04	5.42	4.78	6.34
1000	5.22-8.00	4.71-5.74	3.33-5.57	5.74-7.04
0/100/0	6.96	5.65	5.52	7.05
2000	5.65-8.55	5.30-6.24	5.40-5.64	5.57-8.80
2/20/78	7.82	4.08	4.98	7.22
1000	5.55-10.10	3.09-5.06	4.96-5.01	6.14-8.33
2/20/78	7.19	6.05	5.23	7.08
2000	6.96-7.43	5.46-6.65	5.15-5.30	5.84-8.31
15/52/33	6.21	4.94	5.10	6.55
1000	4.84-7.76	4.16-5.80	4.23-7.05	4.76-8.20
15/52/33	7.55	6.58	6.68	7.04
2000	6.37-9.43	6.06-7.56	5.54-8.29	6.54-7.71
30/0/70	6.02	5.98	4.72	7.06
1000	5.93-6.10	5.40-6.45	4.18-5.26	7.02-7.10
30/0/70	6.46	5.53	5.14	6.70
2000	5.92-7.00	5.30-5.76	4.50-5.79	5.96-7.44

So far as resting oxygen consumption was concerned, changes similar to those of pulmonary ventilation were observed. The oxygen consumption decreased in all experimental regimens below the pre-period and post-period means. It was lowest on the 1000-Calorie regimens; and addition of 1000 Calories to a given nutrient combination raised the oxygen consumption. It was not so low in starvation as it was in the 1000-Calorie regimens.

TABLE III. 112

RESPIRATORY FUNCTION: RESTING OXYGEN CONSUMPTION
(Mean and Range, ml/min)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	267	267	299	316
	209-344	218-305	27[illegible]	[illegible]-334
ST 0	322	243	250	311
	258-370	217-291	[illegible]-291	[illegible]-348
0/100/0	302	260	216	300
1000	238-322	[illegible]-293	197-234	276-316
0/100/0	303	238	229	342
2000	268-334	243-283	231-245	[illegible]-321
2/20/78	310	217	226	315
1000	281-340	177-237	[illegible]-236	325-336
2/20/78	334	277	293	312
2000	329-346	250-304	[illegible]-271	267-358
15/52/33	305	241	240	309
1000	2[illegible]-365	206-271	218-275	251-368
15/52/33	211	218	263	320
2000	249-292	250-309	241-286	297-351
30/0/70	290	262	237	323
1000	287-292	218-276	227-248	316-331
30/0/70	297	255	261	306
2000	290-305	218-292	229-304	285-328

Respiratory quotient showed consistent changes also. During experimental periods it was always lower than in pre-periods. When fat was a major component of the nutrient combination, addition of 1000 Calories had little effect on the R.Q.; if anything, it was depressed. When carbohydrate was a major component, addition of calories raised the R.Q. If one adopts the classical interpretation of R.Q. (i.e., that a rise in it represents a shift toward the burning of more carbohydrate) these data are consistent.

Our findings are similar to those of all others who have worked with low calorie diets. A low calorie regimen leads to diminution in metabolism (Lusk, 1928). We have contributed to knowledge of the relative effects of calories per se and the nutrient combination. One can explain the diminution in pulmonary ventilation on the basis that the production of CO_2 is decreased in the experimental periods. This decreases the necessity for the respiratory center to maintain the pre-period pulmonary ventilation to get rid of the excess CO_2. The decrease in oxygen consumption may be related to a decreased total specific dynamic action from the nutrient combinations presented to the subjects. The decrease in R.Q. may be explained on classical grounds as associated with an

STAT
STAT

TABLE III. 113

RESPIRATORY FUNCTION: RESTING GROSS RESPIRATORY QUOTIENT
(Mean and Range)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	0.87	0.92	0.83	0.86
	0.78-0.94	0.86-1.01	0.74-0.92	0.84-0.92
ST 0	0.87	0.84	0.74	0.88
	0.72-0.97	0.71-0.99	0.65-0.80	0.81-0.98
0/100/0	0.87	0.81	0.78	0.86
1000	0.79-0.96	0.76-0.92	0.70-0.83	0.81-0.90
0/100/0	0.99	0.82	0.86	1.01
2000	0.78-0.98	0.80-0.84	0.74-0.88	0.76-1.50
2/20/78	0.88	0.70	0.76	0.92
1000	0.78-0.99	0.69-0.71	0.75-0.76	0.88-0.97
2/20/78	0.89	0.78	0.74	0.90
2000	----	0.77-0.79	0.68-0.79	----
15/52/33	0.86	0.74	0.75	0.86
1000	0.80-0.94	0.69-0.80	0.72-0.80	0.81-0.89
15/52/33	0.88	0.86	0.87	0.84
2000	0.82-0.92	0.80-0.90	0.79-0.95	0.77-0.88
30/0/70	0.84	0.76	0.74	0.95
1000	0.83-0.84	0.74-0.78	0.67-0.81	0.93-0.97
30/0/70	0.89	0.84	0.69	0.88
2000	0.82-0.94	0.73-0.96	0.68-0.70	0.84-0.92

increase in the percentage of fat burned by the body and a decrease in the percentage of carbohydrate.

In summary, at rest the pulmonary ventilation, the oxygen consumption, and the respiratory quotient all showed changes during restricted regimens that could be correlated with changes in the calorie intake, the nutrient combination, or both.

It is debatable whether any of the changes observed have any teleological significance concerning "survival potential".

Respiratory Function in Exercise-Stress. An exceedingly important aspect of "survival potential" is the capacity to escape and evade. We attempted to obtain as much information as possible on the responses of our subjects to exercise by means of a standardized test on an electric bicycle.

Since the approach was somewhat unorthodox, a brief theoretical statement is necessary. Ordinary exercise such as walking and running involves the moving of mass through a distance, and work (in the physicist's sense) is performed. Most standard machines, such as the bicycle ergometer and the treadmill, necessitate on the part

of the subject the performance of physical work. Now there is another meaning of the term "work", a physiological one. In ordinary language you are "working" when you are employing your muscles; whether or not you move a mass through a distance. You may become physically exhausted pushing against a brick wall, but you accomplish no work (in the physicist's sense). The machine we used, the "Ainoexcle", is built so that the subject's arms, legs and torso are moved for him and he need not cooperate at all. However, his metabolic rate is raised by as much as 500%, he sweats, and he is doing physiological work by his own feelings. Thus, we tested factors that raise the oxygen consumption independent of the performance of true physical work. It is possible that this kind of measurement will reveal changes in the body's economy when a more orthodox treadmill test will not, as the performance of a given amount of physical work is always associated with about the same oxygen consumption, regardless of the condition of the subject if he can work for the required length of time. Figures III. 40, 41, 42 and 43 summarize the results we obtained in experimental periods.

Pulmonary ventilation showed changes in experimental periods as previously discussed in the involuntary exercise. It increased to about 30 liters per minute. In restricted regimens it usually decreased below pre-period values, sometimes very strikingly as in 0/100/0 L 1000 and 30/0/70 L 2000 (See Figures III. 40 and III. 41).

Net oxygen consumption was computed by subtracting (for each subject) his resting oxygen consumption from that measured during the involuntary exercise. Figure III. 43 summarizes these computations. In each restricted regimen (except N 3000) there was a decrease of the net oxygen consumption below the pre-period value for every subject tested. In starvation, the decrease amounted to more than half the pre-period value. Therefore, not only does the resting oxygen consumption decrease, but also the net oxygen consumption caused by involuntary exercise, when the dietary regimen is a restricted one.

Some interesting changes were detected when the net work respiratory quotient was computed. This was done by subtracting for each subject the resting oxygen consumption and carbon dioxide productions from those values obtained for involuntary exercise, and then dividing the net oxygen consumption into net carbon dioxide production. Inspection of figure III. 43 shows that this net respiratory quotient: (1) in eight regimens involving limited water increased in six cases and did not change in two; and (2) in seven regimens with unlimited water decreased in four, increased in two, and did not change in one. Therefore, it might appear that dehydration had a substantial effect upon the net respiratory quotient in this involuntary exercise. The decreased net R.Q. in the unlimited water regimens is associated with a substantial

STAT
STAT

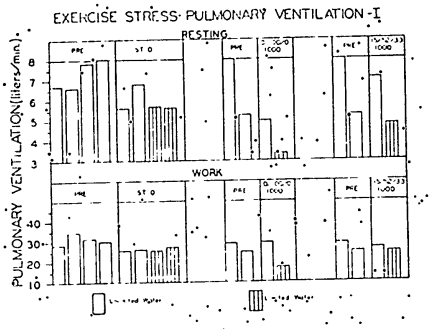

FIGURE III. 40. EXERCISE-STRESS: PULMONARY VENTILATION I.

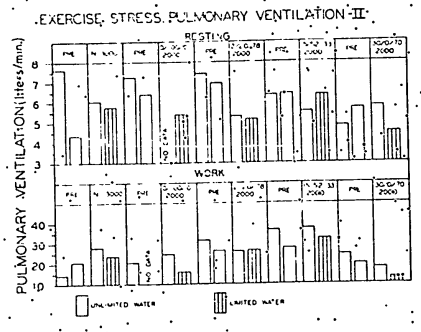

FIGURE III. 41. EXERCISE-STRESS: PULMONARY VENTILATION II.

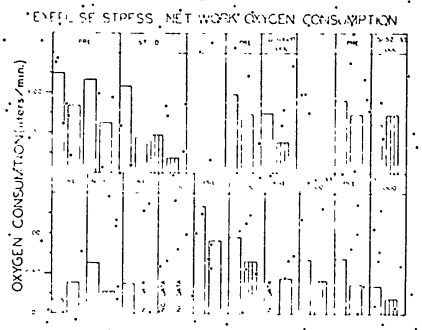

FIGURE III. 42. EXERCISE-STRESS: NET WORK OXYGEN CONSUMPTION.

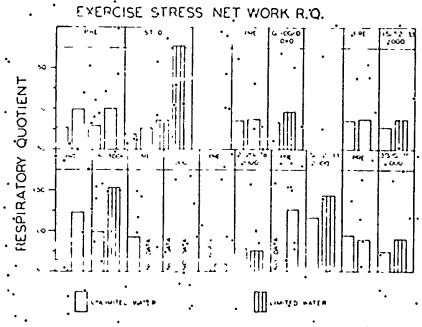

FIGURE III. 43. EXERCISE-STRESS: NET R.Q.

decrease in the CO_2 production.

Decreases such as we have observed in net oxygen consumption during involuntary exercise, and the differential effect of dehydration on the net respiratory quotient are difficult to interpret according to our present knowledge. However, they do suggest a definite response of the body, in one of its most important functions, (energy metabolism), to restricted regimens of calories and of water.

6. Cardiovascular Function

Quantitative measurements were made periodically of resting blood pressure, pulse and circulation time. Also clinical observations were made periodically, supported by readings of the electrocardiogram.

Pre-period data for all subjects at rest are given in Table III. 114. The systolic and diastolic pressures were normal for this age group, being 105 to 120 systolic and 60 to 80 diastolic.

TABLE III. 114

CARDIOVASCULAR FUNCTION: PRE-PERIOD VALUES FOR RESTING BLOOD PRESSURE (mm Hg) AND PULSE (Mean and Range)

Subject No.	Systolic Pressure Mean	Systolic Pressure Range	Diastolic Pressure Mean	Diastolic Pressure Range	Pulse Mean	Pulse Range
1	120	113-129	74	68-80	59	48-68
2	112	97-124	75	64-85	71	58-90
3	129	122-142	80	64-88	72	60-82
4	111	110-112	74	72-76	71	70-72
5	116	112-118	72	69-78	75	70-80
6	122	116-126	68	65-72	72	64-80
7	107	103-114	69	50-68	74	70-78
8	105	102-108	67	56-78	85	84-88
12	107	102-111	64	62-65	70	64-74

The pulse rates also were in the normal range, being 59 in Subject 1 and 85 in Subject 8. Data for these measurements during experimental periods are shown for systolic blood pressure in Table III. 115; for diastolic pressure in Table III. 116; and for pulse rate in Table III. 117.

Systolic blood pressure: The systolic blood pressure decreased (except in 30/0/70) as compared with either the pre-period or the recovery period. It was lowest in the 1000-Calorie regimens, and was not so low in the 2000-Calorie regimens.

TABLE III. 115

CARDIOVASCULAR FUNCTION: RESTING SYSTOLIC BLOOD PRESSURE (Mean and Range, mm Hg)

Nutrient Mixture	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	116	114	116	112
	102-126	98-128	104-126	103-123
St 0	114	110	105	112
	102-130	106-126	95-125	100-126
0/100/0	110	106	104	114
1000	102-116	102-110	98-115	106-124
0/100/0	116	115	113	111
2000	105-129	102-126	103-125	106-120
2/20/78	121	110	112	116
1000	118-124	102-110	108-115	---
2/20/78	116	113	116	118
2000	111-122	106-120	98-134	97-138
15/52/33	116	107	106	116
1000	110-122	105-110	103-116	102-122
15/52/33	117	108	110	119
2000	103-142	98-123	122-122	104-133
30/0/70	104	106	104	108
1000	103-105	104-109	99-108	104-112
30/0/70	106	120	112	110
2000	97-116	114-126	107-118	105-115

Diastolic blood pressure: There were no striking alterations in the diastolic blood pressure during any regimen, a difference of 5 mm Hg not being experimentally significant.

Resting pulse rate: During all restricted regimens, the resting pulse rate decreased significantly from the pre-period value. This happened even during the N 3000 regimen. There was no apparent correlation between this decrease and the absolute calorie intake or the nutrient combination.

Circulation time: Only scattered data were obtained for circulation time, and the results for individual subjects are given in Table III. 118. All values fall within what are usually considered to be the normal limits of the method. However, there were differences between different regimens. In N 3000 and 30/0/70 there were increases in the circulation time. In 15/52/33 and 0/100/0 there were decreases, regardless of calorie intake or water intake.

The clinical interpretation of these changes is not at present clear. It is doubtful if they can be related to potential deterioration, or to "survival potential."

STAT

TABLE III. 116

CARDIOVASCULAR FUNCTION: RESTING DIASTOLIC BLOOD PRESSURE
(Mean and Range, mm Hg)

Nutrient Mixture	Pre-Period	Experimental I	II	Recovery
N 3000	70	70	72	70
	55-85	62-84	60-83	58-83
ST 0	68	73	71	63
	54-82	65-82	65-84	48-75
0/100/0	67	71	68	65
1000	65-69	66-75	66-72	54-76
0/100/0	78	78	78	74
2000	65-98	70-83	68-90	66-80
2/20/78	75	69	74	77
1000	72-78	68-70	74-75	76-78
2/20/78	73	79	70	65
2000	62-84	68-90	59-82	60-70
15/52/33	74	76	70	69
1000	70-80	72-78	68-72	55-82
15/52/33	71	72	68	69
2000	50-86	63-77	60-76	60-79
30/0/70	62	67	65	60
1000	56-67	65-70	62-68	56-65
30/0/70	70	80	77	67
2000	68-72	79-80	76-78	66-68

Clinical observations: The electrocardiograms showed no deviation from the normal at any time, nor were there any changes that could be correlated with the various nutrient combinations, except that there was a bradycardia during restricted periods as previously discussed.

One general group of symptoms was noted with some regularity during starvation and the 1000-Calorie regimens, especially the pure carbohydrate, "black outs" on standing up after reclining were commonly noticed. These were transient, and were characterized by dizziness for a few seconds, and some feeling of faintness. The symptoms suggest a slowness of the cardiovascular system to adapt to changes of position, and were undoubtedly due to orthostatic hypotension. Unfortunately, no quantitative measurements were possible.

General conclusions: Our findings concerning changes in systolic blood pressure and pulse rate are in agreement with the findings of other investigators of low caloric rations. Further, our clinical findings, although minimal, also agree with the work of others (e.g., Smith and Woodruff, 1951). Low caloric rations cannot be considered harmful to the cardiovascular efficiency

TABLE III. 117

CARDIOVASCULAR FUNCTION: RESTING PULSE RATE
(Mean and Range)

Nutrient Mixture	Pre-Period	Experimental I	II	Recovery
N 3000	72	70	62	69
	48-90	49-78	48-78	56-88
ST 0	71	60	56	72
	58-84	42-78	48-64	68-92
0/100/0	78	63	53	69
1000	72-88	56-74	48-74	61-78
0/100/0	66	63	59	60
2000	62-70	50-76	50-76	56-66
2/20/78	68	60	51	67
1000	66-70	56-64	52-60	66-68
2/20/78	77	72	46	75
2000	72-82	70-74	44-48	64-86
15/52/33	75	60	56	68
1000	60-82	47-68	48-64	60-78
15/52/33	74	75	67	79
2000	70-84	72-80	62-74	70-94
30/0/70	79	61	65	76
1000	74-84	50-76	56-74	68-84
30/0/70	66	66	61	64
2000	64-68	56-76	58-64	60-68

unless they lead to extremes, such as "black outs", that might impair "survival potential" by incapacitating the survivor momentarily at a crucial moment.

Oral temperature: Oral temperature was measured daily in the morning, with standard clinical thermometers.

Data for pre-periods are presented in Table III. 119: There were no unusual mean values, nor were the ranges unusual.

During experimental periods, the mean values showed no significant deviations from the pre-period and recovery period values (Table III. 120).

We conclude that the morning oral temperature was not a measure that changed significantly with any regimen at any time, and cannot be used for discriminatory judgements on the merits of the nutrient combinations.

7. Central Nervous System

The functional changes in the central nervous system were:

TABLE III. 118

CIRCULATION TIMES IN INDIVIDUAL SUBJECTS
(Fluorescein Method, Arm to Eye)

Regimen	Subject No.	Circulation Time (Seconds) Pre-Period	Experimental
ST 0 U	3	19.0	17.0
ST 0 L	12	(Missing)	25.4
N 3000 U	7	13.7	18.5
N 3000 L	8	14.8	20.4
30/0/70 U 2000	2	14.7	16.8
30/0/70 L 2000	1	22.3	28.2
15/52/33 U 2000	7	16.4	8.3
15/52/33 L 2000	8	14.2	11.0
2/20/78 U 2000	3	17.5	17.0
2/20/78 L 2000	12	20.3	23.0
0/100/0 U 2000	2	18.5	16.7
0/100/0 L 2000	1	(Missing)	(Missing)
15/52/33 U 1000	6	33.0	21.0
15/52/33 L 1000	5	25.3	10.6
0/100/0 U 1000	6	33.0	27.4
0/100/0 L 1000	5	25.3	24.3

TABLE. III. 119

PRE-PERIOD VALUES FOR RESTING ORAL TEMPERATURE
(Mean and Range)

Subject No.	Temperature °F Mean	Range
1	97.7	97.2-98.3
2	98.0	97.4-99.0
3	97.8	97.7-98.1
4	98.2	98.0-98.4
5	98.2	97.9-98.5
6	97.8	97.5-98.2
7	98.1	97.9-98.4
8	98.3	98.1-98.5
12	97.6	97.3-97.8

appraised by the methods of physical examination, by several psychomotor tests, by quantitative measurement of the passage of time, by psychological tests, and by electroencephalograms. By these devices we sought to measure changes in the higher activities of the nervous system and changes in the psyche. Also by psychological and other devices, data on acceptability of rations and habituation were obtained.

TABLE III. 120

RESTING ORAL TEMPERATURE
(Mean and Range, °F)

Nutrient Mixture	Pre-Period	Experimental I	II	Recovery
N 3000	97.8	97.6	97.8	97.7
	97.2-99.0	97.3-98.1	97.2-98.4	96.8-98.4
ST 0	98.2	98.0	97.6	98.0
	97.8-98.5	97.7-98.4	97.1-98.1	97.2-98.8
30/0/70	97.9	97.8	97.7	98.2
1000	97.3-98.1	97.1-98.0	97.1-98.2	98.0-98.6
0/100/0	97.8	97.8	97.5	97.9
2000	97.3-98.3	97.1-98.2	96.7-98.0	97.4-98.2
2/20/78	98.0	98.0	97.5	97.9
2000	97.8-98.1	97.9-98.0	96.9-98.1	97.6-98.2
2/20/78	97.8	97.8	97.8	97.6
2000	97.8-97.9	97.5-97.7	97.7-97.9	97.4-97.9
15/52/33	97.8	97.6	97.7	97.9
1000	97.6-98.0	97.4-98.1	97.1-98.1	97.3-98.4
15/52/33	98.1	98.1	98.1	98.5
2000	98.0-98.4	97.9-98.5	97.7-98.4	98.1-99.0
30/0/70	98.0	97.7	98.3	98.4
1000	97.8-98.1	97.4-97.9	98.0-98.6	98.3-98.6
30/0/70	98.0	97.8	97.8	98.0
2000	97.7-98.2	97.5-98.1	97.2-98.3	97.9-98.2

Neurological Examinations. As a part of the routine complete physical examination, which was made at regular intervals (at the end of the pre-period and of the experimental period), a neurological examination was made. The following neural functions were tested: deep tendon reflexes, abdominal and cremasteric reflexes, cranial nerve reflexes, vibratory sense, position sense, sense of light touch, response to pin-prick, sense of heat and cold, grip strength, squatting test; Romberg test, and Babinski reflex. The most remarkable finding was the variability in the customarily tested reflexes both among the subjects and from test-period to test-period. No trends were evident which suggested that the several nutrient mixtures had a consistent effect on the neurological processes. The observations made then are only of clinical and diagnostic interest and will not be detailed in this report. These findings are not surprising for generally such tests as were conducted are purely qualitative. When repeated observations are made by the same experienced observer, it is a common finding that isolated reflexes, for example, may show responses ranging all the way from hyperactive to absent in the same subject. The reason for this variability is not clear, but it may be related to such factors as room temperature, previous heavy physical work, lack of sleep and so on. It is only when the abnormal reflexes form a

definitive pattern that one can be sure that serious dysfunction of the central nervous system is developing. Furthermore, such patterns are usually correlated with complaints referable to the nervous system.

Clinical Observations. The only relevant neurological observations made by the subjects during the experiment concerned the pure carbohydrate and the high fat regimens. In the former, one of the subjects (No. 3) complained of constant jitteriness and nervousness after about ten days of 0/100/0 2000. He was on limited water. All four subjects on 2/20/78 reported that their extremities tended to "go to sleep" more easily than normal. The complaint was spontaneously given by the two men (Nos. 5 and 6) who were fed this mixture at 1000 Cal/day; it was elicited from those on 2000 Cal/day. The phenomenon apparently would appear merely when the hands or feet were resting in normal positions such as sitting, reading, or sitting and writing. Generally, the extremities develop peculiar sensations called "going to sleep" when pressure is made over a sensory nerve for a long time; e.g., sitting with legs crossed or with arm hanging over the back of a chair or bench. Normally the condition is reversible; the sensations clear up rapidly after removal of the pressure. Occasional paralysis may develop with a long convalescence. The "Saturday-night paralysis" of the alcoholic who falls asleep on the park bench with his arm hanging across the back rest is a characteristic syndrome. Here prolonged pressure on the radial nerve leads to paralysis and wrist drop from which recovery is slow. Whether the high fat diet in some way made the sensory nerves more susceptible to pressure is a moot point. Since the etiology of the syndrome has not been sufficiently delineated, we record the observation but offer no explanation.

Psychomotor Reactions. The reflex time and the reaction times to sight, sound, and touch were measured at the end of the pre-period and the experimental periods. The results of our observations are summarized in Table III. 121. There are no evident trends in these data in relation to (1) caloric intake, (2) water intake, or (3) nutrient mixture.

Psychological Tests. Judgment of time. The subject's judgment of the passage of time was measured against a stop-watch operated face down by the subject. Three intervals of time were measured: 20 seconds, 45 seconds, and 70 seconds. The pre-period data for the estimates of these intervals are shown in Table III. 122. Seven subjects tended to overestimate the passage of time; two to underestimate it. Subject 4 was only tested twice so that his data may not be representative of his usual performance. The observations for changes in the passage of time in relation to changes in the experimental nutrient mixtures are given in Tables III. 123, 124, and 125. Several findings stand out on examination of these tables. (1) Relative to the pre-period, the subjects either showed no

TABLE III. 121

MEAN REFLEX AND REACTION TIME IN RELATION TO EXPERIMENTAL REGIMEN

Nutrient Mixture	Water	Reflex Time Pre	Reflex Time Exp	Sight Pre	Sight Exp	Sound Pre	Sound Exp	Touch Pre	Touch Exp
		sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.
N 3000	U	.147	.148	.203	.189	.178	.208	.169	.146
	L	.165	.17	.185	.192	.188	.214	.191	.181
ST D	U	.153	.141	.192	.215	.247	.205	.205	.204
	L	.185	.218	.221	.201	.227	.181	.191	.167
0/100/0	U	.155	.169	.179	.185	.171	.197	.193	.188
1000	L	.165	.168	.207	.200	.193	.214	.188	.197
0/100/0	U	.215	.194	.169	.195	.233	.203	.162	.181
2000	L	.141	.191	.203	.209	.215	.260	.211	.238
2/20/78	U	.149	.174	.175	.200	.169	.177	.171	.146
1000	L	.150	.177	.204	.179	.227	.219	.194	.176
2/20/78	U	.156	.167	.197	.176	.193	.232	.152	.173
2000	L	.140	.154	.157	.181	.195	.197	.159	.135
15/52/33	U	.166	.157	.186	.179	.240	.204	.164	.165
1000	L	.178	.144	.184	.169	.176	.170	.180	.146
15/52/33	U	.214	No	.239	No	.204	No	.238	No
2000	L	.138	data	.153	data	.184	data	.162	data
30/0/70	U								
1000	L				No data				
30/0/70	U	.140	.069	.175	.176	.233	.202	.108	.123
2000	L	.175	.208	.218	.187	.297	.189	.216	.139

TABLE III. 122

PRE-PERIOD DATA FOR PASSAGE OF TIME
(Mean and Range)

Subject No.	20 Seconds* Mean	20 Seconds* Range	45 Seconds* Mean	45 Seconds* Range	70 Seconds* Mean	70 Seconds* Range
1	23.7	19.3-25.3	46.2	40.0-53.5	76.8	65.6-90.9
2	20.2	15.5-24.1	48.2	43.0-57.2	77.0	67.9-94.9
3	20.6	19.2-23.5	54.6	47.3-61.0	82.8	72.2-93.7
4	9.0	---	27.0	---	69.5	---
5	20.8	18.6-22.5	49.0	41.1-54.5	76.4	64.5-85.8
6	19.3	11.0-23.9	42.0	25.2-53.7	64.4	43.0-73.6
7	23.6	9.0-39.2	57.8	37.0-75.0	82.0	72.0-97.3
8	21.7	18.4-24.0	51.9	42.0-57.0	81.9	69.0-87.5
12	22.0	16.8-23.4	51.5	34.8-61.0	79.6	71.0-93.4

*Interval of time given to estimate against stop-watch.

TABLE III. 123

PASSAGE OF TIME. I. 20 SECONDS
(Mean and Range)

Nutrient Mixture	Unlimited Water in Experimental Period			
	Pre-Period	I	II	Recovery
N 3000	22.0	23.6	23.1	23.7
	15.5-29.6	17.8-35.9	19.4-31.8	20.7-27.4
ST 0	19.6	26.4	21.5	20.5
	19.3-19.8	19.3-22.4	19.8-22.5	16.1-22.2
0/100/0	24.0	23.6	24.4	20.5
	23.9-24.0	24.6-25.5	24.4-24.5	20.4-20.6
1000	22.3	23.8	24.2	29.8
	21.6-23.0	20.0-27.5	21.0-27.5	26.9-32.7
0/100/0	22.5	14.3	17.5	17.6
	----	----	----	----
2000	21.2	23.0	23.4	23.4
	----	----	----	----
2/20/78	23.8	23.7	20.7	18.7
1000	22.4-25.3	20.6-26.8	20.4-21.0	17.8-19.6
2/20/78	23.6	27.2	26.1	23.0
2000	9.0-38.2	23.4-31.0	13.6-38.6	----
15/52/33	21.3	17.2	19.2	22.5
1000	----	----	----	----
15/52/33	24.1	23.0	21.7	21.4
2000	----	----	----	----

Nutrient Mixture	Limited Water in Experimental Period			
	Pre-Period	I	II	Recovery
N 3000	21.1	22.0	23.6	20.2
	19.2-22.9	18.6-25.8	19.9-27.4	19.4-21.8
ST 0	20.7	24.1	23.8	21.0
	18.9-22.3	20.6-28.8	22.7-24.7	18.3-24.3
0/100/0	21.8	24.6	28.5	22.8
	20.9-22.7	20.7-36.5	19.5-37.5	21.7-24.0
1000	21.0	21.6	20.8	21.2
	20.6-21.5	19.3-23.6	20.5-21.1	20.7-21.7
0/100/0	19.4	21.1	21.8	21.2
	----	----	----	----
2000	16.8	21.6	23.2	20.6
	----	----	----	----
2/20/78	19.9	20.0	24.1	19.6
1000	18.0-21.8	16.2-23.7	23.0-25.2	16.2-22.9
2/20/78	23.6	25.4	23.8	18.2
2000	23.5-23.8	22.1-28.4	20.4-27.2	16.9-19.6
15/52/33	22.1	31.1	33.4	23.0
1000	----	----	----	----
15/52/33	20.4	20.2	19.8	25.0
2000	----	----	----	----

TABLE III. 124

PASSAGE OF TIME. II. 45 SECONDS
(Mean and Range)

Nutrient Mixture	Unlimited Water in Experimental Period			
	Pre-Period	I	II	Recovery
N 3000	48.4	52.3	52.8	59.5
	41.1-61.6	47.0-64.4	49.2-60.0	49.2-72.6
ST 0	46.2	52.8	49.1	53.8
	42.8-49.1	49.3-49.6	49.5-59.4	37.5-71.3
0/100/0	55.4	60.4	60.6	49.6
	53.7-57.0	59.6-61.3	52.7-64.4	47.4-51.7
1000	57.0	53.7	54.5	51.0
	52.7-57.2	52.3-55.1	53.8-55.2	50.2-55.8
0/100/0	50.5	43.9	55.8	46.4
	----	----	----	----
2000	61.0	57.8	54.6	3 9
	----	----	----	----
2/20/78	53.2	55.1	47.0	43.0
1000	49.0-58.5	53.2-61.3	----	38.2-47.9
2/20/78	49.6	64.0	63.2	57.8
2000	27.0-72.3	61.0-67.1	46.7-79.6	----
15/52/33	53.2	47.0	55.2	44.8
1000	----	----	----	----
15/52/33	45.5	46.1	47.7	42.2
2000	----	----	----	----

Nutrient Mixture	Limited Water in Experimental Period			
	Pre-Period	I	II	Recovery
N 3000	46.7	46.5	55.2	44.0
	40.0-54.5	40.4-53.5	48.6-67.1	39.2-52.7
ST 0	50.0	51.3	50.2	51.1
	42.5-57.2	44.0-59.7	46.1-60.4	47.6-58.5
0/100/0	61.7	42.8	57.4	59.2
	49.4-75.0	36.4-49.2	44.0-70.7	53.7-64.7
1000	51.1	45.8	51.4	49.9
	45.5-56.7	36.3-55.3	47.5-55.2	47.6-52.2
0/100/0	52.2	53.0	47.2	43.1
	----	----	----	----
2000	39.8	41.4	52.4	41.7
	----	----	----	----
2/20/78	49.6	49.0	52.6	41.6
1000	44.9-54.5	48.2-49.8	45.5-59.8	36.9-46.2
2/20/78	56.6	56.1	59.4	43.8
2000	56.2-58.0	50.8-61.4	51.1-67.8	42.6-45.0
15/52/33	53.0	63.3	76.2	62.4
1000	----	----	----	----
15/52/33	44.0	52.2	48.0	63.5
2000	----	----	----	----

TABLE III. 125

PASSAGE OF TIME. III. 70 SECONDS
(Mean and Range)

Nutrient Mixture	Unlimited Water in Experimental Period			
	Pre-Period	I	II	Recovery
N 3000	70.4	78.1	60.1	84.4
	64.5-74.0	68.2-93.0	66.8-93.5	73.4-102.2
ST 0	77.1	83.4	79.1	77.5
	73.0-85.8	76.4-96.7	70.8-91.3	60.1-87.8
0/100/0	78.9	83.4	88.5	70.8
1000	70.3-87.5	70.1-96.8	85.8-91.2	67.6-74.0
0/100/0	80.4	89.1	73.0	100.1
2000	82.0-94.9	82.5-95.7	73.8-75.2	83.2-117.0
2/20/78	80.0	75.8	80.2	71.4
1000	----	----	----	----
2/20/78	93.2	89.3	76.2	75.9
2000	----	----	----	----
15/52/33	82.2	90.2	81.8	63.4
1000	73.6-90.9	73.5-107.0	79.1-85.4	57.6-69.2
15/52/33	83.4	98.8	86.1	81.8
2000	69.5-97.3	81.3-98.2	80.2-92.0	----
30/0/70	82.7	69.1	67.7	69.7
1000	----	----	----	----
30/0/70	71.4	75.0	88.0	74.0
2000	----	----	----	----

Nutrient Mixture	Limited Water in Experimental Period			
	Pre-Period	I	II	Recovery
N 3000	71.2	75.9	86.4	71.9
	65.0-78.8	70.9-80.5	73.3-99.0	66.5-80.2
ST 0	78.6	82.8	87.8	78.4
	57.4-93.4	72.3-94.3	84.0-92.4	65.8-95.0
0/100/0	84.5	87.6	91.3	88.8
1000	76.5-92.5	82.3-93.8	69.4-113.2	66.8-110.7
0/100/0	75.6	84.6	74.2	79.3
2000	71.7-79.5	78.3-90.8	69.8-78.5	76.6-82.0
2/20/78	73.6	77.3	78.2	74.2
1000	----	----	----	----
2/20/78	73.0	69.4	80.8	75.8
2000	----	----	----	----
15/52/33	76.4	81.7	89.6	78.4
1000	67.9-72.8	78.6-84.8	81.3-97.9	73-92.6
15/52/33	87.7	90.0	95.6	----
2000	81.7-93.7	78.6-101.3	77.8-113.4	67.2--
30/0/70	75.2	123.2	92.2	95.2
1000	----	----	----	----
30/0/70	82.3	87.7	70.0	99.3
2000	----	----	----	----

appreciable change in judgments of time or tended to overestimate the intervals. There were no instances in which underestimates predominated. (2) Overestimates tended to be augmented by restriction of water. (3) Overestimates tended to be greater at 0 Cal/day and 1000 Cal/day than at 2000 Cal/day and 3000 Cal/day. (4) The influences of water and caloric intake tended to be more pronounced the greater the given interval of time. (5) No consistent relationships between nutrient mixture and judgments of time were evident. The relation between restricted water and estimates of passage of time was confirmed on two alternate subjects who went 72 hours without food or water (see Appendix II).

The interpretation of these findings in the light of current psycho-physiological knowledge is difficult. Possibly these changes represent profound alterations in the activity of the master control clock described by Hoagland (1936). If a lower alters the rate of this reaction, it is not unreasonable to suppose that both deprivation and caloric deficit might also influence the reaction by disturbing the milieu in which occur the fundamental chemical processes responsible for the normal functioning of the higher centers of the nervous system.

Paired comparison tests and a semantic differential scale of attitudes [illegible] tests (see Appendix VI) were conducted in order to find out whether or not the subjects showed any alterations in their reactions toward one another and toward certain aspects of their daily existence both as subjects on a restricted regimen and as students in an academic institution. Only a limited amount of the data collected have been subjected to any detailed analysis.

During the course of the experiment one of the subjects was accused of cheating by his fellows. Examination of the data revealed that although the two groups of subjects may have been homogeneous from the point of view of physical attributes, they were quite different psychologically. Group II was composed of three graduate students and one professional student. On the whole it appeared more mature and intelligent. One member of Group I was a graduate student, but the others were not and they were less mature. They tended to be rated lower by each other and by the members of Group II. Group II, being more homogeneous was, also more cohesive and tended to rate one and another higher on the various traits. At first these psychological differences produced no outward manifestations. The subjects seemed to be a reasonably compatible group of young men. The psychological tests, however, revealed that an underlying hostility was developing. Early in the investigation, two members were rated lower than the other subjects. One was aggressive, the other submissive and he even had marked negative or neutral feelings toward himself. Under the stresses of the many restrictions imposed upon the subjects, it is natural to expect that they would become resentful of the conditions. These

feelings might become overt given sufficient stimulation. The crisis developed during the regular spring recess when the above submissive subject was granted permission, for perfectly bona fide reasons, to break the regimen and go home for a few days. He was shortly thereafter accused of cheating and the entire group manifested hostility toward the subject and the responsible investigators. The principal accuser, it turned out, had developed clear antagonistic feelings toward this subject several weeks prior to the overt episode of accusation. The responsible investigators were convinced that this episode represented a "scapo-goat" phenomenon. The resentment of the subjects against the entire scheme of things became positive. Several weeks were required for repercussions of this episode to disappear. The accuser never did return to his original feelings toward the other subjects or the responsible investigators. As the end of the regimen neared most of the remaining subjects, on the other hand, became more friendly again and admitted that the experience had not been too trying after all. This entire cycle was a perfectly reasonable reaction of any group living under restricted conditions. Overt hostility among the members of the group and toward the authority-figure gradually waned as the experience progressed and the end neared as the experience drew to a close and anticipation of release became the chief thought. To use a homely expression: There is a pecking-order in every group of homeotherms.

Preferences for components of experimental diets: A second paired-comparison test was formulated to gather information on the acceptability of the ration components used in the experimental diets. Since this test was administered bi-weekly, it was also possible to find out if any appreciable changes took place in the preferences in relation to the regimen on which the subjects were subsisting at the time of the test. One important point must be remembered in interpreting these data. This study was not an acceptability trial of certain components. If the components became tiresome or produced symptoms, isocaloric substitutions were made so that, if possible, the metabolic effects of two weeks on a particular nutrient combination could be studied. Under actual survival conditions, the only mitigation of a tiresome ration would be from foods obtained from natural resources - "living off the land."

The detailed data of such preferences are given in Appendix II. In Table III. 126 we summarize the important trends: (1) On all regimens (Column 1), the first two choices were spice drops and meat bar and the last two choices were chocolate bar and cereal biscuit. This polarity is in complete agreement with the incidence of gastrointestinal complaints. (2) In only one particular regimen did the trend deviate from the grand total; viz., starvation. When the subjects were fasting, the preference for meat bar fell from second to fifth place. This shift may be another expression of the craving for carbohydrate noted in discussion of Table III. 43.

TABLE III. 126

PREFERENCES FOR RATION COMPONENTS IN RELATION TO REGIMEN AT TIME OF TESTING*

Rank-Order of Preference	All Regimens	Pre-Period 3000	0/100/0	30/0/70	2/20/78	1.1/32/33	Unlimited Water	Limited Water	3000 Cal/day	1000 Cal/day	0 Cal/day
First	G	G	M	G	G	M	G	G/J	G	M	G
Second	M	M	G	M	L	G	M	---	M	G	J
Third	L	L	Ch	J	J/M	L	L/J	L	L	J	Ch
Fourth	J	J	L	L	---	J	---	J	J	L	L
Fifth	Ch	Ch	C	C	Ch	C	C	Ch	C/Ch	C	M
Sixth	C	G	J	Ch	C	Ch	Ch	C	--	Ch	C

*Key:

G = Gum Drops (spice drops)
M = Meat Bar
L = Life Savers
J = Starch Jelly Bar
Ch = Chocolate Bar
C = Cereal Biscuit

Habituation to 5-in-1 ration: One of the major problems of any prolonged use of a limited menu is monotony. This factor is important in the maintenance of the morale of fighting men required to subsist for many weeks or months on packaged rations which offer only a small choice of different foods. With continued use the troops become habituated, refusing to eat the food in adequate amounts with consequent weight loss. When a restricted menu is available, it is the ingenuity of the cooks which delays and even prevents the development of habituation. The truth of these statements was amply attested by experience of nutritional observers (Johnson and Kark, 1947) in World War II. These investigators presented evidence that even avitaminoses might develop when habituation became severe enough --- the while an adequate ration was available for eating.

In the present investigations efforts to avoid habituation were made in two directions: (1) diversification of menus and (2) use of fresh food supplements to the 5-in-1 ration in the recovery period. A number of acceptable recipes employing components of the 5-in-1 ration were devised (see Appendix III). These recipes markedly improved the willingness of the subjects to continue eating the 5-in-1 ration during 13 of the 21 weeks of the investigation. In spite of careful and ingenious menu planning, habituation did

begin to appear. There was no trend in weight change (see Table VI. 46). This fact indicated that in general the caloric balance was being adequately maintained between experimental periods. The striking sign was an increasing complaint about the meat items of the 5-in-1 ration: salty ham chunks, greasy beef and gravy, unpalatable pork and gravy, and sameness of taste to the meats generally. Quantitative evidence that these complaints represented habituation is summarized in Table III. 127. In this table are shown the means of the pre- and recovery periods for total calories, calories from meat, and the percent of the total calories derived from meat during each succeeding phase of the investigation. Four

TABLE III. 127

HABITUATION TO MEAT COMPONENTS OF 5-IN-1 RATION

	Pre-Period			Recovery		
Phase	Total Calories	Meat Cal	Meat % Total	Total Calories	Meat Cal	Meat % Total
I	3097	1086	35	3839	876	23
II	3239	1062	33	4584	896	20
III	3920	1095	28	4668	896	19
IV	3847	993	26	4226	854	20
V	3357	897	27	3897	738	19
Mean	3492	1027	30	4243	852	20

significant observations stand out: (1) With the total caloric intake remaining relative constant in the pre-period there was a marked reduction in the absolute intake of meat during the last two phases. (2) There was also a gradual decrease in the percentage of the total calories derived from meat. (3) A similar absolute decrease in meat occurred in the recovery periods but there was no corresponding change in the relative amount of meat. (4) When the pre- and recovery periods were compared, in spite of the larger amount of total calories consumed in the latter, there was a marked absolute and relative decrease in the amount of meat eaten. In the recovery period the choice of foods was greater so that if the meat items were not preferred, the subjects could eat other foods and still satisfy their caloric demands. Apparently this is exactly what the subjects did. The marked diminutions in meat intake during the last two phases corroborated the qualitative evidence that complaints about the food increased toward the end of the investigation.

These marked trends raise the question: What foods were eaten in place of the meat so as to maintain the caloric intake? A breakdown of the foods into several categories was made in an attempt to answer this question. The results are summarized in Table III. 128. In so far as the pre-period is concerned, the categories meat, fruits and vegetables, crackers and jam, and desserts and

TABLE III. 128

PERCENT OF CALORIES FROM VARIOUS FOODS
DURING PRE-PERIODS AND RECOVERY

	Pre-Period						Recovery		
Phase	Meat	Fruits and Veg	Crackers and Jam	Desserts and Candy	Other	Total	Meat	Suppl	Total
I	35	10	35	15	5	100	23	49	72
II	33	12	34	14	7	100	20	46	66
III	28	12	31	18	11	100	19	47	66
IV	26	9	33	18	14	100	20	49	69
V	27	11	26	19	15	100	19	53	72
Mean	30	11	32	17	10	100	20	50	69

candy accounted for about 90% of the total calories. Since the percentage of total calories accounted for by these categories decreased to the same extent as did the meat category alone, these data do not account for the maintenance of the caloric intake. Further review of the figures on food intake reveals that increased intake of such foods as oleomargarine, peanut butter, and orange juice -- which were added to the pre-period regimen to provide variety -- were the responsible foods. In the recovery period, the supplements (fresh bread, oleomargarine, orange juice, and ice cream) made up 50% of the caloric intake. This category plus meat accounted for 69% of the total caloric intake. The large intake of these supplements allowed the subjects to maintain their caloric intakes without eating such large amounts of meat as in the pre-period.

In summary, we have presented definitive evidence that habituation to 5-in-1 is a real phenomenon and that the foods most commonly complained of were the meat components of the ration. Some habituation was present after only two weeks on 5-in-1. Habituation became a more serious problem after about two months of subsistence of the ration. There was then a marked absolute decrease in the consumption of meat both in the pre-period and the recovery period. Whereas our conditions were most ideal for delaying this phenomenon, under field conditions with unimaginative or untrained cooks, habituation would probably become a serious problem in a much shorter time. Here is a technological problem requiring the attention of the food experts of the Armed Forces.

Electroencephalography. The analyses of the data from the electroencephalograms have not been completed. Under the conditions of the present study no abnormal electroencephalograms were obtained from any of the subjects at any time on any of the experimental regimens.

E. HEMATOLOGY

Systematic hematologic measurements were made repeatedly throughout all periods by means of standard methods (Ham, 1952). The battery of measurements included hemoglobin, hematocrit, total serum protein, erythrocytes, indices of erythrocyte size and shape, leukocytes, thrombocytes and erythrocyte sedimentation rate. All original data have been collected in Appendix II. For the most part what will be discussed in the present section is positive findings, the most interesting change of all having been observed in the erythrocyte sedimentation rate.

1. Hemoglobin

Pre-period data for hemoglobin are given in Table III. 129. The hemoglobin was normal for males of this age group, and showed but little change in the several pre-periods. During the several experimental periods it showed some fluctuations (Table III. 130). It tended to increase in all experimental periods, and sometimes went as high as 17.9 gm per 100 ml.

TABLE III. 129

PRE-PERIOD DATA FOR HEMATOLOGY: RED CELL COUNT, HEMOGLOBIN, HEMATOCRIT, AND SEDIMENTATION RATE DURING PRE-PERIODS

Subject No.	Red Cell Count M	σ	C.V.	Hemoglobin M	σ	C.V.	Hematocrit M	σ	C.V.	Sedimentation Rate (Corr.) M.	σ	C.V.
	mill/mm³		%	gm/100 ml		%	%	%	%	mm/hr		%
1	4.78	0.06	1.3	14.7	0.7	5.2	44	1.9	4.3	5	1.0	200
2	5.00	0.15	3.0	16.4	0.7	4.3	48	2.8	6.3	5	2.8	56
3	4.71	0.13	2.8	16.0	0.5	3.1	45	1.1	2.4	2	1.0	50
4	4.65	----	---	16.0	---	---	45	---	---	6	---	---
5	5.02	0.11	2.2	16.3	0.5	3.1	46	1.2	2.4	3	2.4	80
6	4.72	0.08	1.7	15.5	0.5	3.2	45	2.1	4.7	4	0.8	20
7	4.51	0.11	2.4	15.3	0.4	2.9	43	1.6	3.7	8	2.0	25
8	4.56	0.16	3.5	15.2	0.6	3.9	44	1.5	3.4	2	2.0	100
12	4.94	0.09	1.8	16.8	0.6	3.3	48	1.6	3.3	6	2.5	42

These changes may be interpreted as related to the state of body hydration, and not to the formation of new hemoglobin. It will be recalled that even in regimens of unlimited water there was a tendency toward negative water balance.

2. Hematocrit

The percentage of whole blood contributed by red cells in general fluctuates in normal persons with the concentration of hemoglobin, especially in dehydration. Data for this measurement in

TABLE III. 130

HEMATOLOGY: HEMOGLOBIN, gm/100 ml

Nutrient Mixture	Unlimited Water in Experimental Period Pre-Period	I	II	Recovery
N 3000	16.2	16.3	16.7	16.8
	15.2-17.0	15.2-17.0	16.0-17.4	15.6-17.4
ST 0	16.2	16.8	16.9	15.5
	15.6-17.0	16.0-17.4	16.4-17.9	14.3-16.0
0/100/0	15.4	15.8	15.4	15.6
1000	15.2-15.6	15.6-16.0	15.2-15.6	15.2-16.0
0/100/0	15.8	17.2	17.2	15.8
2000	15.6-16.0	16.4-17.9	16.4-17.9	15.6-16.0
2/20/78	16.4	17.0	17.0	16.0
1000	----	----	----	----
2/20/78	15.2	17.4	14.7	16.4
2000	----	----	----	----
15/52/33	15.2	15.0	15.2	15.0
1000	----	14.7-15.2	14.7-15.6	14.7-15.2
15/52/33	15.4	15.6	15.4	15.2
2000	14.7-16.0	14.7-16.4	14.7-16.0	----
30/0/70	14.3	15.2	16.0	14.3
1000	----	----	----	----
30/0/70	15.6	17.0	17.0	16.4
2000	----	----	----	----

Nutrient Mixture	Limited Water in Experimental Period Pre-Period	I	II	Recovery
N 3000	15.4	15.6	15.9	15.5
	14.7-16.4	15.2-16.4	15.6-16.4	15.2-15.6
ST 0	16.8	17.6	17.4	15.5
	16.0-17.4	16.4-18.4	16.4-18.9	14.3-16.4
0/100/0	16.2	16.7	16.7	15.4
1000	16.0-16.4	16.4-17.0	16.4-17.0	14.7-16.0
0/100/0	15.0	15.6	15.8	14.8
2000	14.3-15.6	14.7-16.4	14.7-17.0	14.3-15.2
2/23/78	15.6	16.0	16.0	15.6
1000	----	----	----	----
2/20/78	17.4	17.9	17.9	16.4
2000	----	----	----	----
15/52/33	16.0	17.0	16.4	15.8
1000	15.6-16.4	----	----	15.2-16.4
15/52/33	15.6	15.8	14.7	15.6
2000	14.7-16.4	14.7-17.0	----	14.7-16.4
30/0/70	15.2	16.0	17.0	15.2
1000	----	----	----	----
30/0/70	13.5	15.6	15.6	15.2
2000	----	----	----	----

STAT
STAT

pre-periods is shown in Table III. 129, and for experimental periods in Table III. 131.

In pre-periods our subjects had normal values (43 to 48 volumes per 100 ml blood) with but little fluctuation from pre-period to pre-period. During experimental regimens, the mean value went as high as 51, and then subsided again in recovery periods. We interpret these increases as representing a state of relative dehydration in all experimental periods, regardless of water intake, as the data for body water support this conclusion.

3. Total Serum Protein

The total serum protein may alter with state of body hydration. In chronic malnutrition it sometimes decreases to low levels, especially when protein intake has been low. Our results support the idea that the brief period of protein depletion suffered by the subjects did not significantly deplete the serum protein. On the other hand, there was no convincing evidence that it did increase in response to known tissue dehydration. See Table III. 132 for pre-period data, showing normal values for all subjects, and Table III. 133, which shows no recognizable trend in experimental periods.

4. Erythrocytes

All the data for red cell counts are in Appendix II. No abnormalities worth mentioning were detected at any time in any subject.

5. Erythrocyte Indices

Wintrobe (1946) popularized a group of three indices which are extremely useful in classifying and diagnosing anemias. These represent the average properties of the red cell of any individual. In words, they represent the volume of the individual's average red cell, its amount of hemoglobin and the concentration of hemoglobin in it.

In our subjects no significant deviation from normal was observed during pre-periods (Table III. 134) or in experimental periods (Appendix II).

6. Erythrocyte Sedimentation Rate

The sedimentation rate is the speed with which red cells settle in blood under standard conditions. It is a very important measurement in clinical medicine, as it correlates very well with the rate of progress in chronic and acute inflammatory diseases, such as rheumatic fever. According to most hematologists it is a non-specific reaction, but an accelerated rate is definitely suggestive of organic disease. The blood changes which lead to its acceleration are but poorly understood, but it is known that factors in the

TABLE III. 131

HEMATOLOGY: HEMATOCRIT, %

Nutrient Mixture	Pre-Period	Unlimited Water in Experimental Period I	II	Recovery
N 3000	46	47	48	48
	42-51	43-50	45-51	45-51
ST 0	47	50	49	44
	44-50	48-52	48-50	42-46
0/100/0	44	45	44	44
1000	42-45	44-46	44-45	42-47
0/100/0	45	49	50	46
2000	44-46	48-50	48-51	--
2/20/78	49	50	50	40
1000	--	--	--	--
2/20/78	45	50	43	41
2000	--	--	--	--
15/52/33	44	44	45	45
1000	43-44	43-46	43-47	44-46
15/52/33	44	45	45	44
2000	42-45	--	--	--
30/0/70	42	47	46	43
1000	--	--	--	--
30/0/70	46	49	50	47
2000	--	--	--	--

Nutrient Mixture	Pre-Period	Limited Water in Experimental Period I	II	Recovery
N 3000	45	46	46	46
	43-46	43-48	43-47	45-47
ST 0	48	51	51	43
	46-51	49-52	49-52	40-46
0/100/0	48	49	50	45
1000	46-50	47-50	--	42-48
0/100/0	44	46	46	44
2000	43-44	44-47	44-47	--
2/20/78	46	47	46	44
1000	--	--	--	--
2/20/78	49	49	50	47
2000	--	--	--	--
15/52/33	48	50	48	46
1000	47-48	49-50	48-49	44-49
15/52/33	45	45	44	44
2000	43-47	44-47	43-45	42-47
30/0/70	43	46	47	42
1000	--	--	--	--
30/0/70	42	48	48	46
2000	--	--	--	--

STAT

TABLE III. 132

PRE-PERIOD DATA FOR TOTAL SERUM PROTEIN
(gm/100 ml)

Subject No.	Mean	σ	C.V. %
1	7.3	0.3	3.9
2	7.2	0.2	2.4
3	7.1	0.3	4.2
4	---	---	---
5	7.1	0.3	4.1
6	7.0	0.2	3.6
7	6.6	0.3	4.2
8	7.3	0.2	3.0
12	6.9	0.2	2.9

TABLE III. 133

AVERAGE SERUM PROTEIN
(gm/100 ml)

Nutrient Mixture	Water	Pre-Period	Experimental I	Experimental II	Recovery
N 3000	U	6.6	6.8	7.0	7.1
	L	7.1	7.5	7.2	6.8
ST 0	U	7.0	7.7	7.8	6.8
	L	6.9	7.1	6.7	7.0
0/100/0 1000	U	7.4	7.0	6.4	6.7
	L	7.2	7.2	6.7	7.5
0/100/0 2000	U	7.1	7.2	7.1	7.0
	L	6.9	7.4	7.2	7.1
2/20/78 1000	U	6.9	7.5	6.3	6.9
	L	7.0	---	7.1	6.6
2/20/78 2000	U	7.7	6.8	6.6	6.6
	L	6.9	7.1	6.9	6.8
15/52/33 1000	U	7.1	7.2	6.8	7.2
	L	7.2	6.4	6.6	---
15/52/33 2000	U	6.4	7.1	7.6	7.0
	L	7.0	7.7	7.2	6.4
30/0/70 1000	U	7.7	7.4	6.3	6.2
	L	7.1	7.2	6.8	7.0
30/0/70 2000	U	7.4	7.2	6.8	7.4
	L	7.6			

TABLE III. 134

PRE-PERIOD DATA FOR HEMATOLOGY: MEAN CORPUSCULAR VOLUME, MEAN CORPUSCULAR HEMOGLOBIN AND MEAN CORPUSCULAR HEMOGLOBIN CONCENTRATION DURING PRE-PERIODS

Subject No.	Mean Corpuscular Volume M	σ	C.V.	Mean Corpuscular Hemoglobin M	σ	C.V.	Mean Corpuscular Hemoglobin Concentration M	σ	C.V.
	μ3	μ3	%	μμg	μμg		%	%	%
1	93.4	5.3	5.8	30.8	1.9	6.2	33.0	1.1	3.0
2	95.6	4.3	4.5	32.8	1.2	3.7	34.3	1.0	2.9
3	96.4	3.4	3.5	33.6	1.0	3.0	35.1	1.5	2.3
4	97.0	---	---	34.5	---	---	35.5	---	---
5	97.3	1.1	1.1	32.4	0.6	1.9	33.4	0.6	1.8
6	96.8	5.9	6.1	33.2	0.9	2.7	34.2	1.4	2.4
7	96.0	3.6	3.8	34.1	1.0	2.9	34.5	1.8	1.0
8	95.6	1.4	1.5	33.2	0.7	2.1	33.7	1.4	2.4
12	96.0	1.6	1.7	34.0	0.9	2.6	35.4	0.7	2.0

plasma, such as fibrinogen, albumin, and globulin, have a great deal to do with the phenomenon (Wintrobe, 1946). In our experiments, the changes in sedimentation rate were consistent and striking.

During pre-periods the mean values were entirely normal for all subjects, and the variations remained within normal limits for all pre-periods (Table III. 129). During experimental periods, however, increases appeared in several regimens (Figure III. 44). The usual finding was an increase in the first week of all regimens, followed by a drop in the second.

The changes, with one exception, were most striking in those regimens which provided the most protein: N 3000, 30/0/70, and 15/52/33 2000. The exception was a sharp increase in the first week of 2/20/78 2000 at a time when the subject was ill. The change during starvation might be attributable to tissue breakdown; i.e., endogenous protein metabolism. There was no clear or consistent relation between sedimentation rate and water intake.

This measurement is one which can be used to rank-order the various nutrient combinations. Until proved otherwise, we must interpret it in the orthodox clinical manner; an increase must be considered as indicative of undesirable changes in the body. It may be that it is a sensitive response to stress.

STAT
STAT

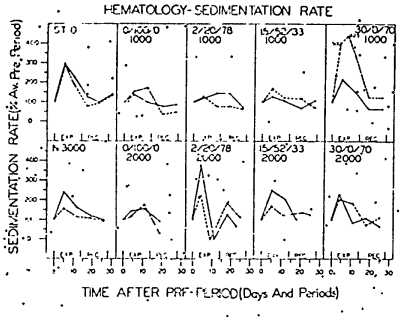

FIGURE III. 44. HEMATOLOGY: SEDIMENTATION RATE.

Corrected to Hematocrit of 47%. Continuous Line, Unlimited Water; Dashed Line, Limited Water.

7. Leukocytes

Complete studies were made of the white cells of the blood. The pre-period data for all subjects are shown in Table III. 135 and showed normal values. There were no abnormal changes, outside the experimental error of the method, in any experimental period (Appendix II).

It had been expected that the eosinophils would show changes in concentration with the experimental regimens, as these white cells are said to decrease in stress. However, in our experiments they were no more discriminatory than any other white cell.

8. Thrombocytes

No abnormal findings are to be reported in respect to the blood platelets. See Table III. 135 and Appendix II for complete data.

TABLE III. 135

PRE-PERIOD DATA FOR HEMATOLOGY: WHITE CELL COUNT, NEUTROPHIL COUNT, LYMPHOCYTE COUNT, DIRECT EOSINOPHIL COUNT AND DIRECT PLATELET COUNT DURING PRE-PERIODS

Subject No.	White Cell Count M	σ	C.V.	Neutrophils M	σ	C.V.
	cells/mm³		%	cells/mm³		%
1	8,360	462	5.5	4,770	420	8.8
2	8,100	460	5.7	4,010	517	12.9
3	7,270	844	11.6	3,810	734	19.3
4	8,150	---	----	4,090	---	----
5	8,360	1,130	14.0	3,570	775	21.7
6	8,040	876	10.9	4,460	442	9.9
7	8,340	671	8.0	3,540	324	9.1
8	7,770	434	5.6	4,460	298	6.6
12	8,740	1,420	16.3	4,270	789	18.4

Subject No.	Lymphocytes M	σ	C.V.	Direct Eosinophil Count M	σ	C.V.	Direct Platelet Count M	σ	C.V.
	cells/mm³		%	cells/mm³		%	cells x 10^3/mm³		%
1	3,250	317	9.8	118	18	15.2	260	16	6.2
2	3,860	487	12.6	133	34	25.6	241	22	9.1
3	3,200	321	10.0	129	15	11.6	230	18	7.8
4	4,070	---	----	144	--	----	256	--	----
5	4,020	391	9.7	217	55	25.3	282	26	9.2
6	3,410	428	12.5	104	39	37.5	233	18	7.7
7	4,440	535	12.1	224	45	20.1	270	23	8.5
8	3,110	368	11.8	49	6	12.2	256	40	15.6
12	3,890	518	13.3	259	56	22.4	219	9	4.1

9. General Conclusions on Hematology

The observations on leukocytes, thrombocytes, and the properties of the red cells proved to be non-contributory in the present study, except to prove that the subjects remained normal throughout with respect to these blood cells. Neither were abnormal changes detected in the serum protein.

Changes were observed in the whole blood hemoglobin and hematocrit; these changes were most logically attributable to changes in the state of hydration.

The one striking change was in the sedimentation rate and this change may well be related to the stress of restricted regimens,

STAT
STAT

and may be a measure of success in coping with these stresses.

F. CLINICAL EVALUATIONS OF NUTRIENT COMBINATIONS

The extensive data in the preceding pages have clearly demonstrated that the unusual nutrient mixtures tested produced marked alterations in the functioning of the organs and systems of the body. The magnitude of the changes frequently, however, was within the limits of normal. The question arises: "Were the strains placed upon the homeostatic mechanisms reflected in the appearance of clinical symptoms and signs?" It can perhaps be argued that if the organs and systems of the castaway continue to function within the expected range of normal while he is subsisting on a given nutrient mixture, all is well for him, the particular dietary regimen can be tolerated, and his survival potential is not seriously impaired. Such a point of view might be satisfying to those who concern themselves solely with the functions involved. It is, however, the castaway who has to survive and not so much the function. The holistic approach requires that we look at the whole man and his environment. If clinically significant reactions are associated with the functional deviations, then we should revise our estimates of the usefulness for survival of a given nutrient mixture.

The subjects of the present investigation developed clinically significant signs and symptoms and in many cases these alterations were associated with demonstrable functional deviations. The clinical correlations lend credence to the chemical changes not associated with symptoms. The latter deviations argue that a breakdown may have been impending. Perhaps the added stresses of hard work and heat or cold would have precipitated a clinical event. Such hypotheses will be tested in field trials which are planned for the near future. In the following paragraphs we shall summarize some of the more outstanding clinical events which occurred in our volunteers.

<u>High Fat-Low Carbohydrate and Protein, 2000 Cal/Day.</u> Two subjects (Nos. 3 and 12) subsisted on this regimen. The foods used were an experimental chocolate bar, saltines, and oleomargarine, the latter items being substitutes for the bar when it became unacceptable. Subject 3 was on unlimited water. It was not until day 3 that complaints developed. The bar was described as a greasy tasteless mass. His legs began to tire, especially on climbing stairs. On day 4 he began to substitute crackers and oleo for the bar. He stated that he was nauseated, all tired out and was having loose stools. On days 5 and 6 he felt better, but on day 7 stated that he was having more nausea and also abdominal cramps. These complaints became minimal, but weakness in the legs and growing intolerance toward the nutrient mixture persisted. The bar was gradually eliminated from the ration because it caused nausea. On the last three days of the regimen, the total caloric intake

decreased to about 1000 Cal/day. More was intolerable.

Subject 12 was on limited water. After his first meal he became nauseated. The bar tasted like wax. He would rather starve than eat it. Crackers and oleo were substituted but, because of nausea, he was unable to consume 2000 calories. Cramps and loose stools developed on day 2. On day 3 he ate his ration in smaller feedings and the nausea decreased. Abdominal cramps, pains in the chest and back on the right, and inability to sleep were his chief complaints. His entire intake of calories was from crackers and oleo. Symptoms continued on days 4 and 5. On day 6 he had loose stools again. On day 7 he stated that cramps were increasing and localizing in the epigastrium. Subject spent more and more time in bed. He was unable to eat 2000 Cal/day. On day 8 he developed intense nausea and there was a small amount of emesis after breakfast. After the evening meal he experienced the sudden onset of acute dull pain in the right upper quadrant which caused him to double up. Acute pain lasted about 30 minutes and then subsided spontaneously. Examination revealed slight tenderness in right upper quadrant. Peristaltic activity was reduced. There were no palpable organs or masses. On day 9 dull R.U.Q. pain was still present. Right nipple was tender and chest pain located at level of tip of scapula frequently radiated through to the back. He experienced no emesis. Examination revealed a suggestion of a palpable mass (? gall bladder) in the right upper quadrant. The subject was unable to eat because of fear of provoking a second attack of pain. He stated that on day 5 his legs began to "go to sleep" more easily and that this condition persisted. "Blacking out" was also present. On day 10 he was taken off the diet. At noon he ate some jelly sandwiches which precipitated a mild attack of R.U.Q. pain. He felt somewhat improved. An X-ray study of the stomach, small intestine, and gall bladder was done on day 11. These organs were found to be normal. A calcified cyst of unknown origin was found in the liver. It was the opinion of the attending physicians that this cyst was not the basis for the clinical reactions of the patient to the high fat regimen.

This clinical picture suggests that there may have been an underlying disturbance of the functioning of the gall bladder and possibly the liver. Both subjects 3 and 12 exhibited functional deviations of the liver (Figure III. 45). In the case of subject 3 the disturbances became evident during the recovery period. There was a marked increase in urinary urobilinogen to levels above the upper limits of normal and a concurrent depression of serum cholinesterase. The cephalin flocculation reaction did not become positive, suggesting that the impairment of liver function was not marked. The serum amylase (? pancreatic function) remained normal. On the other hand, the more intense clinical event experienced by subject 12 was correlated with chemical changes developing during the experimental period. There was an increased excretion

STAT
STAT

ORGANIC FUNCTIONAL REACTION-I

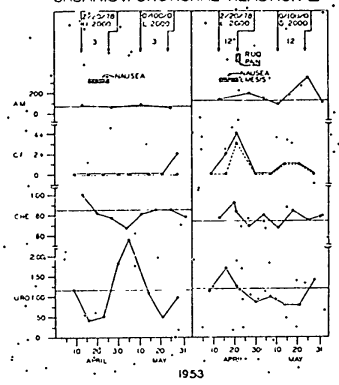

FIGURE III. 45. ORGANIC FUNCTIONAL REACTIONS. I.

Changes in Serum Amylase, Cephalin Flocculation, Serum Cholinesterase, and Two-Hour Urobilinogen Related to Consumption of High Fat and High Carbohydrate Diets at 2000 Cal/day.

AM = serum amylase, amylase units/100 ml. CF = cephalin flocculation, 24-hr reaction (dashed line) and 48-hr reaction (continuous line). CHE = serum cholinesterase, pH/hr. URO = urobilinogen, E.U./2 hr. Continuous lines for AM, CHE, and URO represent individual subject's pre-period average.

of urobilinogen and a marked increase in the cephalin flocculation reaction. A four plus reaction is usually associated with significant disturbance of liver function. The serum cholinesterase rose transiently and then returned to the usual levels observed in this subject. Concurrently there was an elevation of the serum amylase suggesting that the exocrine function of the pancreas was also involved. We interpret this clinical event as an episode of biliary dyskinesia. Such a diagnosis implies that the neurogenic mechanism regulating the emptying of the gall bladder was unbalanced in such a way that the gall bladder was contracting against a spastic ampulla. The latter spasm may account for the

elevated serum amylase.

Subjects 5 and 6 who were on this nutrient mixture at 1000 Cal/day exhibited decreases of serum cholinesterase which persisted into the recovery period.

Recovery of subject 3 was uneventful and associated with a return of biochemical levels toward "normal." Subject 12 was placed on pavarine and phenobarbital. His recovery was slow and marked by increasing anxiety over the liver cyst. After repeated reassurances, he finally straightened out. Since the final experimental regimen was pure carbohydrate, it was decided to keep him on as a subject. A high carbohydrate diet is well-known as good therapy for liver dysfunction.

High Carbohydrate, 2000 Cal/Day. Four subjects subsisted on this nutrient mixture. All subjects repeatedly remarked that this diet provoked minimal thirst, even when the water intake was unlimited. The excessive sweetness was tolerated, but dental cavities became painful, especially during the first few days. No. 2 complained of tiredness and loss of physical stamina. Nos. 1 and 12 experienced frequent "black-out" spells, which the latter stated were worse than during starvation. No. 3 became jittery and restless during the second week.

The clinical symptoms suggested that circulatory dysfunction may have developed to a greater or lesser extent. In spite of the lack of symptoms pointing to the liver, chemical alterations developed (Figure III. 45). The changes exhibited by subjects 3 and 12 are typical of the reactions shown by all four men. The urinary urobilinogen and serum cholinesterase of subject 3 were not disturbed. A two-plus cephalin flocculation reaction during the rehabilitation period pointed to early liver disturbance. Subject 12 reacted more strikingly. The cephalin flocculation reaction became positive during the experimental period and remained so through the recovery period. There was a concurrent large increase in serum amylase. These functional changes during the carbohydrate diet were unaccompanied by clinical symptoms. Subjects 1 and 2 also developed two-plus cephalin flocculations in the recovery period.

High Fat-High Protein, 1000 Cal/Day. Two subjects subsisted on the high fat-high protein ration at 1000 Cal/day. Subject 8, who was on unlimited water intake, ate the nutrient mixture with relative ease for the full 14 days. On day 2 he began to complain of fatigue. Hunger developed the next day and continued for the remainder of the experimental period. The fatigue, on the other hand, was progressive. On day 6 he reported that he was "slooping in a drunken stupor" from which it was difficult to arouse him. On day 8 he remarked that his legs felt like lead weights and that he was experiencing cramps in his gastrocnemii. These various

STAT
STAT

symptoms tended to moderate during the remainder of the period and there were no further complaints.

Subject 7, who was on limited water, reacted in a strikingly contrasting manner. On day 2 he began to experience fatigue. The next day he complained of hunger. On day 4 he began to look fatigued. He slept a great deal, and it was difficult for him to stay awake or concentrate on intellectual tasks. By day 6 he began to complain of difficulty ingesting the meat bar. "It tastes like a blob of grease, sticking in my throat." The taste was almost continuously present and he felt nauseated. He looked drawn, thin, and flushed, and circles appeared under his eyes (day 7). This clinical deterioration was accompanied by marked biochemical changes: azotemia, ketonuria, hemoconcentration, and relative lymphocytosis. Because of these changes, it was decided to increase the caloric value of the ration with 1000 Cal/day of carbohydrate and maintain the water intake at 900 ml/day. Within 24 hours there was a substantial clinical improvement. The subject did not feel so tired and he felt more energetic. His thirst, however, did not ameliorate and his lips became dry and cracked. The ketonuria disappeared within this period. After two days on this regimen there was little additional improvement and some marked personality changes appeared. The subject became bitter, moody, and caustic. The azotemia persisted as did the hemoconcentration. There was a reduction of the relative lymphocytosis but the neutrophils showed the presence of toxic granules.

The organic functional reactions experienced by these two subjects are illustrated in Figure III. 46. Ketonuria was marked in both men during the first week. It rapidly subsided in subject 7 after carbohydrate was added to the diet. Changes in liver function were relatively small. Subject 7 showed no increase in cephalin flocculation, a small decrease in serum cholinesterase in the recovery period, and an elevated excretion of urobilinogen. Subject 8 showed a transient increase in cephalin flocculation; a rise and then a fall of serum cholinesterase, and only a small peak in urinary urobilinogen. The symptoms of these men cannot be accounted for in terms of deviations in liver function, nor can the contrasting behavior of the men be so explained. Furthermore, it is doubtful that ketosis is the explanation of the syndrome (Fisher, 1950). Review of the data on caloric balance (Figure III. 2) suggests that both men were equally in negative balance. Serum electrolytes did not change appreciably (Table III. 97). Study of the mineral balance shows that in spite of the reduced intake, the two subjects tended to remain in balance (Figures III. 9-12). In the recovery periods, however, there was a very large positive balance with respect to potassium and a relatively small positive balance with respect to sodium and chloride. This suggests that there was a relatively great replacement of intracellular substance and water. The relatively greater dehydration of subject 7 (Figure III. 24) must have been achieved at the

ORGANIC FUNCTIONAL REACTIONS-II

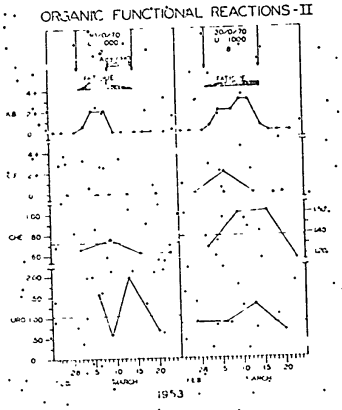

FIGURE III. 46. ORGANIC FUNCTIONAL REACTIONS. II.

Changes in Ketonuria, Cephalin Flocculation, Serum Cholinesterase, and Two-Hour Urobilinogen Relation to Consumption of Meat Bar at 1000 Cal/day.

KB = qualitative ketonuria (Rothera). All urine specimens tested had been diluted to 2000 ml. CF = cephalin flocculation, 24-hr reaction (dashed lines) and 48-hr reaction (continuous lines). CHE = serum cholinesterase, pH/hr. URO = urobilinogen, E.U./2 hr. Continuous lines for CHE and URO represent individual subject's pre-period average.

expense of intracellular water. Perhaps the clue to the syndrome lies here.

Meat Bar and Cereal Bar, 2000 Cal/Day. Four subjects, 3, 4, 7, and 8 subsisted on this regimen. Subjects 4 and 7 were on unlimited water and experienced relatively little difficulty going the full 44 days of the experimental period. During the first week subject 4 felt nauseated both before and after breakfast: This symptom was minimal at the times of the other meals. He had a persistent sick feeling in the abdomen which was probably caused

STAT
STAT

more by final examinations than by the diet. His stools were looser than normal, but he did not have diarrhea. During the second week most of these complaints disappeared and he became used to the ration. The most remarkable finding was the gradual reduction of water intake. Subject 7 was tested on this diet in late May and early June when the weather was excessively warm and humid. Subject 7 completed the 14-day period without undue difficulty. His major complaint was nausea, especially after eating. The nausea was principally due to the cereal biscuit. After seven days he could no longer tolerate this component, and so he was given crackers and jam in addition to meat bar, which yielded an approximately isocaloric nutrient mixture.

Except for the nausea, then, this mixture with unlimited water was tolerable. The limitation of water produced a marked accentuation of these symptoms. Subject 3 was tested in January. The weather was not conducive to sweating. On day 5 he began to complain of a dry mouth, fatigue, and lack of ambition. These complaints continued until the eighth day when he reported that it was becoming increasingly difficult to eat the ration. It kept "repeating" all day. On day 9 he vomited once in the morning. He complained of thirst, fatigue, unsteadiness, and generalized aches. The ration caused nausea and he felt nauseated all day. Physical examination revealed a tired pale individual who was well oriented. There were no gross abnormalities. Because of his complaints, it was decided to discontinue the ration. Subject 8, on the other hand, was tested in late May and early June during a period of hot humid weather. He rapidly developed severe clinical symptoms. On day 2 he felt thirsty and depressed. Nausea was present and he did not feel normal. On days 3 and 4 he felt somewhat better. His tongue was only moderately coated. In spite of extra water allowances, however, the urinary specific gravity rose to 1.039 and he began to complain of tiredness, weakness, aching in legs, and light-headedness. He was pale and his tongue was coated. The urinary sediment showed no casts or red blood cells. On day 6 the symptoms were still present, and the urinary specific gravity had dropped to 1.034. Because of a complaint of pain and tenderness in the region of the kidneys, a fresh urinary specimen was collected and examined. There was no albumin but the sediment contained an excessive amount of mucus and occasional finely and coarsely granular casts. He was given 1100 ml of extra water. On day 7 he felt miserable: nauseated, dizzy, weak, tired, anoroctic, and depressed. Pains in legs and high lumbar region were still present. Although the weather was excessively hot and humid, he stopped sweating and in 500 minutes passed only 195 ml of urine. The specific gravity was 1.036. Again the sediment contained a large amount of mucus and occasional finely and coarsely granular casts. He was given the water tolerance test, the results of which did not indicate excessive dehydration. During the first hour, however, he felt dizzy and began to sweat profusely. One plus pitting odema was detected along the shins. With unlimited water the

recovery was rapid and most of the complaints disappeared within 48 hours. The edema did likewise. Presumably the failure to lose weight after day 4 was due to water retention. This subject probably was suffering from early heat exhaustion.

Concurrent alterations in liver function are summarized in Figure III. 47. The principal observation is that there was a more marked decrease in serum cholinesterase and elevation of urobilinogen in the case of the men on limited water than in the case of those on unlimited water. Subject 8, whose symptoms were the most severe, also developed a 2+ cephalin flocculation reaction. Again, in the presence of a high solute load, a limited water intake accentuated the clinical picture and led rapidly to severe dysfunction. The hot weather during the period when subject 8 was on the regimen, merely acted to augment the negative water balance. That this subject was dehydrated, was shown by the elevation of the serum chloride from 100 to 109 mEq/l.

Again, these subjects remained close to balance in spite of the markedly reduced intake of K, Na, P, and Cl. That the balance was precarious, is shown by the rapid deterioration under heat stress. Whether or not the symptoms of subject 8 were heat cramps cannot be categorically answered. The cessation of sweating was probably due to early heat disease. The rapid clinical response to water suggests that dehydration more than heat cramps was the basic cause.

Positive Control. Support for this conclusion comes from the reactions of subject 6 who was subsisting on positive control and limited water during this same spell of hot humid weather. The weather was hot, with daily maximum temperatures ranging between 95° and 98°F. Because of sweating, thirst developed rapidly. By day 4, he was complaining of extreme thirst and soreness of the tongue. Hoarseness developed after 15-20 minutes of talking. The tongue was heavily coated with thick, furry café au lait colored material. In spite of moderate allowances of extra water to make up for the sweat loss, the urinary specific gravity rose. On day 5 it was 1.037. Hyaline casts (5,400/2 hr) were present in the urinary sediment and the urinary urobilinogen was elevated, 1.62 Ehrlich Units/2 hr (normal for subject, 0.81 E.U./2 hr). Because these observations suggested early renal dysfunction, disturbed liver function, and dehydration, the subject was taken off the restricted water regimen. On day 6 he was given the water tolerance test, 20 ml/kg of body weight. Within the four-hour period after ingesting 1200 ml of water, neither the minute urine volume nor the urinary specific gravity changed. He retained all the water. He responded rapidly to free-water intake and continued the remainder of the experimental regimen without complaint.

This subject lost 6% of his body weight in five days and the serum chloride rose from 99 to 109 mEq/l. By all evidence he was

STAT
STAT

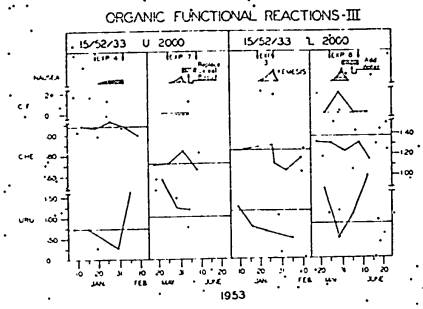

FIGURE III. 47. ORGANIC FUNCTIONAL REACTIONS. III.

Changes in Cephalin Flocculation, Serum Cholinesterase, and Two-Hour Urobilinogen in Relation to Consumption of Meat Bar Plus Cereal Biscuit at 2000 Cal/day.

CF = cephalin flocculation, 24-hr reaction (dashed lines); 48-hr reaction (continuous lines); CHE = serum cholinesterase, pH/hr. URO = urobilinogen, E.U./2 hr. Continuous lines for CHE and URO represent individual subject's pre-period average.

markedly dehydrated. Because of the high solute load, especially sodium chloride, he did not become salt deficient. His complaints were those of simple dehydration. He responded rapidly to liberal quantities of water. The symptoms were different from those of subject 8 (vide supra) and suggest that in the latter the circulatory complaints and muscular pains may have had their origin in a condition of heat exhaustion brought on by incipient salt deficiency. The remarkable response to water exhibited by both men, however, strongly implicates dehydration.

Comment. These clinical-chemical correlations suggest that in the cases where chemical changes were observed in the absence

recovery was rapid and most of the complaints disappeared within 48 hours. The edema did likewise. Presumably the failure to lose weight after day 4 was due to water retention. This subject probably was suffering from early heat exhaustion.

Concurrent alterations in liver function are summarized in Figure III. 47. The principal observation is that there was a more marked decrease in serum cholinesterase and elevation of urobilinogen in the case of the men on limited water than in the case of those on unlimited water. Subject 8, whose symptoms were the most severe, also developed a 2+ cephalin flocculation reaction. Again, in the presence of a high solute load, a limited water intake accentuated the clinical picture and led rapidly to severe dysfunction. The hot weather during the period when subject 8 was on the regimen, merely acted to augment the negative water balance. That this subject was dehydrated, was shown by the elevation of the serum chloride from 100 to 109 mEq/l.

Again, these subjects remained close to balance in spite of the markedly reduced intake of K, Na, P, and Cl. That the balance was precarious, is shown by the rapid deterioration under heat stress. Whether or not the symptoms of subject 8 were heat cramps cannot be categorically answered. The cessation of sweating was probably due to a fairly heat disease. The rapid clinical response to water suggests that dehydration more than heat cramps was the basic cause.

Positive Control. Support for this conclusion comes from the reactions of subject 6 who was subsisting on positive control and limited water during this same spell of hot humid weather. The weather was hot, with daily maximum temperatures ranging between 85° and 95°F. Because of sweating, thirst developed rapidly. By day 4, he was complaining of extreme thirst and soreness of the tongue. Hoarseness developed after 15-20 minutes of talking. The tongue was heavily coated with thick, furry café au lait colored material. In spite of moderate allowances of extra water to make up for the sweat loss, the urinary specific gravity rose. On day 5 it was 1.037. Hyaline casts (6,400/2 hr) were present in the urinary sediment and the urinary urobilinogen was elevated, 1.62 Ehrlich Units/2 hr (normal for subject, 0.81 E.U./2 hr). Because these observations suggested early renal dysfunction, disturbed liver function, and dehydration, the subject was taken off the restricted water regimen. On day 6 he was given the water tolerance test, 20 ml/kg of body weight. Within the four-hour period after ingesting 1200 ml of water, neither the minute urine volume nor the urinary specific gravity changed. He retained all the water. He responded rapidly to free-water intake and continued the remainder of the experimental regimen without complaint.

This subject lost 6% of his body weight in five days and the serum chloride rose from 99 to 109 mEq/l. By all evidence he was

STAT
STAT

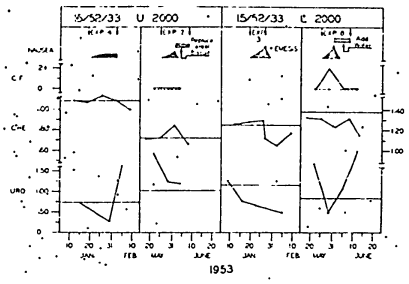

FIGURE III. 47. ORGANIC FUNCTIONAL REACTIONS. III.

Changes in Cephalin Flocculation, Serum Cholinesterase, and Two-Hour Urobilinogen in Relation to Consumption of Meat Bar Plus Cereal Biscuit at 2000 Cal/day.

CF = cephalin flocculation, 24-hr reaction (dashed lines); 48-hr reaction (continuous lines). CHE = serum cholinesterase, pH/hr. URO = urobilinogen, E.U./2 hr. Continuous lines for CHE and URO represent individual subject's pre-period average.

markedly dehydrated. Because of the high solute load, especially sodium chloride, he did not become salt deficient. His complaints were those of simple dehydration. He responded rapidly to liberal quantities of water. The symptoms were different from those of subject 8 (vide supra) and suggest that in the latter the circulatory complaints and muscular pains may have had their origin in a condition of heat exhaustion brought on by incipient salt deficiency. The remarkable response to water exhibited by both men, however, strongly implicates dehydration.

Comment. These clinical-chemical correlations suggest that in the cases where chemical changes were observed in the absence of significant clinical complaints, the subjects were suffering from a chemical lesion which had not yet become severe enough to cause a clinical episode. They further suggest that given the added stresses of a survival situation --- heat, cold, and hard work of escape and evasion --- such a clinical episode might be precipitated. Our data reveal how heat stress accentuates the progression of the chemical deviations. A categorical definition of the nutrient composition, then, must rest on full exploration of the modifications produced by these nutrient mixtures upon the physiological reactions to the stresses of the simulated survival situation.

SECTION IV

DISCUSSION: TABLE OF CONTENTS

A. INTRODUCTION

The purpose of this discussion is to attempt to judge the relative merits of 20 combinations of protein, carbohydrate, fat, calories and water used in this study as described in Sections II and III. Our attention will be centered on the single practical question: Is it possible from our data to settle upon an optimal combination as a potential all-purpose survival ration? We shall not discuss many points of fundamental theoretical importance except in so far as they bear upon the practical question, although many of these points have been raised in Sections II and III.

In order to make these judgments, logical criteria must be established. Among the many measurements which were made in this study, nineteen proved to be discriminatory among the several nutrient combinations, could be quantitatively expressed, and could be logically related to maintenance or deterioration of the survival potential of the castaway. Other quantitative measurements could not be so used, either because they were not discriminatory among nutrient combinations, or because they have not been proved to be predictive of potential damage.

Perhaps more important than these quantitative tests were the clinical observations of the subjects and the objective signs of deterioration. The reason why clinical observations must be considered highly significant is that deterioration in the body as a whole may give rise to detectable signs and symptoms before there are measurable physiological and biochemical deviations from normal. Only one truly serious defect in an otherwise perfect ration could lead to fatal deterioration in a survivor. For example, the incapacitating nausea and excruciating headache frequently caused by the pre-World War II "D Bar" were evoked in the absence of demonstrable biochemical lesions (D. B. Dill, personal communication). This concept of the "weakest link" in an otherwise superior survival ration must be emphasized in any statistical consideration of the various survival rations. It is quite possible that only on clinical grounds can the "weakest link" be detected. In any case, clinical observations must be considered together with the biochemical and physiological data.

1. Biochemical and Physiological Ratings.

All biochemical and physiological measurements have been summarized in a fashion permitting rank-order treatment. For final compilation 19 measurements were tabulated (Table IV. 1); all were logically related to survival potential. Defense of this selection is needed only in general terms. Negative balances of calories,

TABLE IV. 1

RANK-ORDER OF NUTRIENT COMBINATIONS: "SURVIVAL POTENTIAL"

Measurement (Second week of Experimental Period or Lowest Value during Experimental or Recovery Periods)	N	Nutrient Combinations																											
		3000		30/0/70		2000		15/52/33		2000		2/20/78		30/0/70		1000		15/52/33		1000		2/20/78		1000		0/100/0		0	
		U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
Balance																													
1. Calorie	1	2	7	5	3	8	19	15	4	6	14	17	12	16	11	9	13	10	13	20									
2. Water	17	11	11	1	18	1	6	20	2	5	7	15	4	16	6	9	10	12	19	13									
3. Nitrogen	3	2	6	1	5	4	8	19	15	9	12	11	7	10	14	16	11	18	17	20									
4. Sodium	6	3	19	14	10	9	1	4	8	7	18	20	13	11	2	5	17	16	12	15									
5. Potassium	2	1	18	10	19	11	3	7	6	5	17	20	15	14	9	13	12	16	4	8									
6. Phosphorus	3	1	13	2	4	9	10	17	8	12	15	18	16	5	6	7	11	19	14	20									
7. Acid-Base (Ketonuria)	11	4	18	15	4	4	14	4	4	4	20	16	13	9	10	12	8	4	17	19									
Body Composition																													
1. Least loss, body wt.	1	2	8	9	4	3	5	13	7	10	14	16	6	12	11	18	15	17	19	20									
2. Least change, body water	1	11	17	19	5	9	6	12	<	15	3	20	4	16	10	18	7	14	8	13									
Liver Function																													
1. Serum cholinesterase	1	2	5	7	6	17	11	3	4	8	11	10	16	15	13	9	20	18	19	12									
Kidney Function																													
1. Creatinine clearance	4	6	10	14	3	2	9	15	13	7	5	1	19	12	17	18	11	8	16	20									
2. Osmotic Parameters																													
a. Mean urine volume	19	13	18	10	17	11	6	8	16	1	20	12	15	4	5	3	9	2	14	7									
b. U/S ratios	15	20	10	14	4	19	11	17	2	7	3	12	6	18	9	16	1	13	5	8									
3. Addis Count																													
a. Casts	8	8	8	8	8	8	8	8	18	17	8	8	16	8	8	8	8	8	19	20									
b. Red cells	7	7	7	7	7	7	7	7	7	18	19	7	7	7	7	7	17	16	15	20									
Endocrines																													
1. 17-Ketosteroids	2	4	17	14	1	3	20	19	8	5	12	15	13	10	11	6	9	7	18	16									
2. Blood sugar	2	6	14	8	10	13	12	15	1	9	17	18	4	3	16	20	7	5	11	19									
3. Thyroid function (Resting M.R.)	2	3	18	1	4	6	5	9	13	11	14	7	10	15	19	20	16	17	12	8									
Hematology																													
1. Sedimentation rate	15	6	14	11	16	7	19	13	5	10	12	20	2	8	4	1	3	9	18	17									

water, nitrogen, sodium, and phosphorus will lead sooner or later to deterioration. Until proved otherwise, ketonuria must be considered deleterious or at least wasteful of energy. Minimal decreases in body weight and body water must be considered advantageous in survival. Normal functioning of the liver is important; in our study it seemed to be best correlated with serum cholinesterase. Normal kidney function is critical in survival. Creatinine clearance is currently the most popular single measure among clinical investigators of renal function. The osmotic parameters (minimal obligatory urine volume and the U/S ratio) have been discussed fully in Section III; for present purposes mean urine volume and calculated U/S ratios have been used. The Addis count is a quantitative measure of formed elements in the urine which must be considered, when present in abnormal numbers, as evidence of actual or potential tissue damage. Of the three endocrine functions listed, the 17-KS are associated with adrenocortical function, the blood sugar with pancreatic and pituitary function among other relations, and the resulting metabolic rate is usually considered to be correlated with thyroid function. Sedimentation rate of the erythrocyte is increased in a wide variety of recognized pathological conditions and was the sole hematological measure that changed with nutrient composition of the survival rations.

In setting up Table IV. 1, in general, mean values for all nutrient combinations during the second experimental week were assigned rank-order numbers ranging from 1 to 20. Exceptions were made for sedimentation rate, blood sugar, and serum cholinesterase for which the lowest values during experimental or recovery periods were considered to be more significant than the mean value of the second experimental week. In the Addis counts for casts and red cells and in ketonuria, many values of zero were obtained which necessitated assigning to each zero the median value for the series of zeros. The sum of each of the 19 rank-order numbers for each nutrient combination was calculated. In every case, the lowest rank-order number is considered to represent the best effect of the nutrient combination. Therefore, the sum of all the rank-order numbers represents a composite score in which 19 would be perfect and 380 would be worst. For ease of interpretation, the data in Table IV. 1 have been consolidated graphically in Figure IV. 1, which shows for each nutrient combination the rank-order scores as they fell into four quartiles, the best being the first quartile (1-5) and the worst being the fourth quartile (16-20).

Before attempting to discuss Table IV. 1 and Figure IV. 1, it is necessary for us to list quantitative measurements which were not considered pertinent for the present purpose for one of two main reasons. These reasons were: (1) the changes in quantities were so small that an attempt to rank-order the several regimens was absurd or, (2) it was our conviction that the measurements had no relation to the survival potential as currently conceived by the

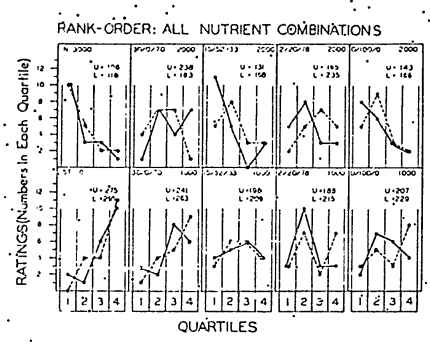

FIGURE IV. 1. RANK-ORDER RATINGS OF ALL NUTRIENT COMBINATIONS.

Frequency Distribution of Scores among Four Quartiles, 1 Being Best and 4 Being Worst. Numbers in the 10 Compartments Represent the Total Score for Each Nutrient Combination.

USAF; viz., ability of the castaway to withstand the stresses of survival for not more than 10 to 14 days. These two classes of measurements have been listed in Table IV. 2. An additional group of measurements was omitted so as not to weight the average rank-order, or because of incomplete data. Among them were: (1) chloride balance (same as sodium balance), (2) change in body water (data not available for all dietary regimens), (3) urine volume, specific gravity, and total urinary solids (more significant data from water balance and osmotic parameters), (4) urinary ammonia (meaning of present test not fully elucidated), and (5) net oxygen consumption during involuntary work (meaning in relation to survival not clear at present stage of knowledge).

Some comment is pertinent to the measurements listed in the left hand column of Table IV. 2. Some of the quantities did change. The changes, however, were either limited to a few individuals or the changes bore no relation to the several dietary regimens. In the former group were urinary urobilinogen, serum cephalin

TABLE IV. 2

MEASUREMENTS STUDIED AND NOT INCLUDED IN TABLE IV. 1 BECAUSE RELATION TO SURVIVAL POTENTIAL UNPROVEN

Quantities Unchanging During Experimental Period	Quantities Teleologically Unrelated Regardless of Experimental Result
	Balances 1. Calcium balance Body Composition 1. Body fat 2. Lean body mass Liver Function 1. Serum cholesterol
Liver Function 1. Urinary urobilinogen 2. Serum cephalin flocculation	
	Renal Function 1. Serum urea nitrogen
Gastrointestinal Function 1. Characteristics of feces	Gastrointestinal Function 1. Fecal fat 2. Fat absorption 3. Nitrogen absorption 4. Occult blood
	Respiratory Function 1. Pulmonary ventilation 2. Respiratory quotient
	Cardiovascular Function 1. Pulse rate 2. Blood pressure 3. Circulation time 4. Electrocardiogram
Endocrine Function 1. Exocrine function of pancreas 2. Serum Na, K, and Cl	Endocrine Function 1. Parathyroid function 2. Urinary creatine (? thyroid)
Hematology 1. Hematocrit	Hematology 1. Red blood count and hemoglobin 2. Blood indices 3. White blood cells 4. Thrombocytes
Central Nervous System 1. Reaction and reflex times 2. Psychological tests 3. Electroencephalograms (analysis incomplete; no abnormalities)	
Blood Chemistry 1. Total serum protein	

flocculation reaction, characteristics of the feces, and exocrine function of the pancreas. In the latter group were the results of the psychological tests. The major changes in the tests we used were related to the regulated conditions of the investigation rather than to the several dietary regimens. The remainder of the measurements showed no significant alterations.

General interpretations of the quantitative biochemical and physiological measurements should be made by examination of Table IV. 1 in conjunction with Figure IV. 1. Three major conclusions are supported by the data. First, no nutrient combination with or without water restrictions scored as high as the positive control at 3000 Cal/day or as low as starvation at 0 Cal/day. Furthermore, no nutrient combination at 1000 Cal/day ranked as high as the same nutrient combination at 2000 Cal/day, water being unrestricted. Therefore, it must be concluded that the paramount aim of survival rations should be to provide as many calories as possible. Second, restriction of water worsened the score of every nutrient combination including starvation, the sole exception being 30/0/70 at 2000 Cal/day. Therefore, a second important aim of survival rations must be to provide water in liberal quantities. Third, it is possible to arrive at a decision concerning the best nutrient combination under the conditions of our experiment. Leaving out of consideration the control ration as impractical, at 2000 Cal/day the 15/52/33 regimen had the best score when water was unrestricted. When water was limited to 900 ml/day the scores were almost equal for 15/52/33 and 0/100/0. At 1000 Cal/day, without limitation of water, 2/20/78 had the best score followed closely by 15/52/33. When water was restricted, 15/52/33 was the best.

The final decisions among these "best" nutrient combinations must be made on clinical grounds for all had defects which might be due to the action of the "weakest link."

2. Clinical Interpretations

In order to facilitate consideration of the clinical data, Table IV. 3 presents the occurrence of symptoms (reports by subjects on feelings either spontaneous or elicited by questioning) and signs (manifestations observed by the medical officer) for each of the nutrient combinations. No attempt has been made to average these data as such a procedure is meaningless in this sort of clinical analysis. Uniformly negative findings have not been listed; e.g., palpability of liver and spleen, stigmata of avitaminosis, and abnormality of neurological findings.

Four clinical episodes occurred which were serious enough to require alteration of the experimental regimen. None occurred in pre-periods, recovery periods, or experimental periods when water was not restricted. They occurred in N 3000 L, 15/52/33 2000 L, 2/20/78 2000 L, and 30/0/70 1000 L. The cases have been discussed

TABLE IV. 3

SYMPTOMS AND SIGNS DEVELOPING DURING EXPERIMENTAL PERIODS

Clinical Observations — Nutrient Combination

(Third line shows number of subjects subsisted on each dietary regimen)

Symptoms	N 3000	30/0/70 2000	15/52/33 2000	2/20/78 2000	0/100/0 2000	30/0/70 1000	15/52/33 1000	2/20/78 1000	0/100/0 1000	ST 0
1. Easy fatigability (including tiredness)	0	0	2	1	1	1	2	1	1	3
2. Weakness	0	0	1	1	1	1	2	1	1	3
3. Hunger (including hunger pangs)	0	0	1	0	1	0	1	0	1	3
4. Anorexia	0	0	0	1	0	1	0	1	0	0
5. Nausea	0	0	1	2	1	0	0	1	0	0
6. Dry mouth	0	0	0	0	0	0	0	0	0	0
7. Vomiting	0	0	0	0	0	0	0	0	0	0
8. Abdominal cramps	0	0	1	0	0	0	0	0	0	0
9. Abdominal pain	0	0	0	0	0	0	0	0	0	0
10. "Diarrhea" (loose stools or true diarrhea)	0	0	0	0	0	0	0	0	0	0
11. Flatus	0	0	0	0	0	0	0	0	0	0
12. Burning anus	0	0	0	0	0	0	0	0	0	0
13. Extremities "falling asleep"	0	0	1	0	0	0	0	0	0	0
14. Jittery, nervous, irritable	0	0	1	1	0	0	1	0	0	0
15. Black-out (including light-headedness)	0	0	1	1	0	0	1	0	0	0
16. Gritty sensation in mouth	0	0	0	0	0	0	0	0	0	0
17. Thirst	0	0	0	0	0	0	0	0	0	0
18. Severe thirst (hoarseness and sore tongue)	0	0	0	0	0	0	0	0	0	0
19. Inability to sleep	0	0	0	0	0	0	0	0	0	0
20. Sleepy "all the time"	0	0	0	0	0	0	0	0	0	0
21. Cramps in legs	0	0	0	0	0	0	0	0	0	0
Signs										
1. Impression of clinical deterioration	0	0	1	0	0	0	2	0	0	0
2. Coated tongue	0	0	0	0	0	0	0	0	0	0
3. Glossal tooth markings	0	0	0	0	0	0	0	0	0	0
4. Edema	0	0	0	0	0	0	0	0	0	0
5. Hemorrhoids	0	0	0	0	0	0	0	0	0	0
6. Canker sore	0	0	0	0	0	0	0	0	0	0
7. Dry cracked lips	0	0	0	0	0	0	0	0	0	0
8. Red tongue	0	0	0	0	0	0	0	0	0	0
9. Tenderness in region of kidneys	0	0	0	0	0	0	0	0	0	0
10. Tenderness in R.U.Q.	0	0	0	0	0	0	0	0	0	0
11. Palpable mass in R.U.Q.	0	0	0	0	0	0	0	0	0	0

in detail in Section III. The general conclusion is that limitation of water was the precipitating factor in all four cases. Important, but subsidiary, were the specific etiological factors: excessively high solute load, especially NaCl, in N 3000; a toxic cereal biscuit in 15/52/33; excessively high fat in 2/20/78 eliciting symptoms of acute gall bladder dysfunction; and high solute load, primarily nitrogenous, in 30/0/70. Supporting evidence may be adduced from the symptoms of other subjects who did not develop conditions requiring alteration of the dietary regimen: 2/20/78 produced nausea in all subjects who ate it, even when water was unlimited; 30/0/70 produced nausea in three of the four subjects who took it; regardless of water intake; and 15/52/33 produced nausea in five of the eight subjects who took it. It should be obvious that whatever nutrient combination is standardized as the all-purpose survival ration; the final product must not possess the undesirable characteristics that might lead to any incapacitating clinical episodes such as we observed.

3. Evidence from the Present Study on the Optimal Nutrient Combination for a Survival Ration

None of the nutrient combinations was without defect. Some of these were intrinsic, others were attributable to the actual food item with which we were provided. The former defects are not remediable technologically; the latter almost certainly are. An unexpected and previously neglected aspect of survival rations is the probable importance of their inorganic constituents in addition to protein, carbohydrate, and fat. The intrinsic defects of 30/0/70 are high solute load and tendency to produce nausea and ketosis; in 2/20/78 the defect is tendency to produce nausea and in 0/100/0 the defect is an effect on the kidney such that red cells and casts appear in the urine. So far as we have been able to determine, 15/52/33 had technological defects only. The cereal biscuit caused gastrointestinal upsets which were obviated by replacement of the biscuit with soda crackers and other forms of carbohydrate. With respect to the 5-in-1 ration, a serious technological defect exists: excessively and undesirably high salt content, which might be dangerous if the 5-in-1 were used as an emergency ration and water were limited.

At present our feeling is that, all things considered, 15/52/33 2000 is the best formula for a survival ration. Technological defects of the present components and additions of small amounts of potassium and phosphorus can be achieved simultaneously by the same change. Our best present recommendation is to provide, per man per day, 2000 Calories of a survival ration in which the nutrient ratios approximate 15/52/33. Such a ration can easily be provided in palatable form from meat bar, bread unit and other carbohydrates, dried fruits, and dried milk. Vitamin pills should be standard.

It is interesting that the survival ration suggested above

approximates in calorie distribution the dietary that is chosen voluntarily by most American soldiers (Johnson and Kark, 1947). It is also very interesting that it is almost the same in nutrient composition and also individual food items to the ration used on his south polar journey by Amundsen (1913), probably the most successful of all polar explorers, and on his journey to the North Pole by Peary (1910) as shown in Table IV. 4. In all of their expeditions neither explorer was adversely affected by malnutrition.

TABLE IV. 4

POLAR EXPEDITIONARY RATIONS OF PEARY AND AMUNDSEN

Components of Ration per man per day	Cal	CHO gm	Fat gm	Prot gm
Peary's North Pole Expedition of 1909				
Pemmicans, 1 lb	2090	83	107	210
Biscuit, 1 lb	2150	330	72	44
Cond. milk, 4 oz	384	66	10	10
Total	4624	479	189	264
% Cal	100	41	37	23
Amundsen's South Pole Expedition of 1911				
Pemmicans, 350 gm	1780	90	110	116
Biscuits, 400 gm	1824	280	48	68
Powdered milk, 120 gm	436	62	2	44
Chocolate, 40 gm.	188	25	12	1
Total	4228	457	172	229
% Cal	100	43	37	22

*Pemmican: Peary's pemmican was stated to contain "dried beef, fat, and raisins," with less fat than beef. Amundsen's pemmican was stated to contain equal weights of dried beef and fat with oatmeal and dried vegetables added.

B. IMPORTANT UNSOLVED PROBLEMS

The present report deals with but one aspect of survival. Our subjects were healthy young men in a temperate environment not exposed to extraordinary stresses and not required to exercise more than moderately. If there is such a thing as a typical survival situation, the castaway is likely to be exposed to emotional and physical stresses, sometimes extreme. He is likely to be exposed to hot or cold weather, he may have to work hard to evade and escape. Perhaps more important than anything else, he may be suffering from physical injury. What are his nutritional requirements under all these various conditions? What is the least injurious survival ration for him? These questions at present are unsolved. Our opinion is that their solution requires painstaking, systematic,

statistically adequate, comprehensive clinical studies in the field on healthy subjects under conditions of environmental extremes and the stress of physical exercise in simulated survival situations and in the hospital on patients with traumatic injuries.

SECTION V

SUMMARY

A. Purposes Of Study.

1. From December 1952 through June 1953, eight volunteer students (and four others for particular validation experiments) served at McKinley University Hospital, University of Illinois, Urbana, in studies that were planned to contribute basic knowledge to the general problem of the all-purpose, all-environment survival ration.

2. The general aims of the study were principally two:

a. To study comprehensively from the standpoint of total efficiency and the functioning of important organs and organ systems, the reactions of healthy young men to a variety of restricted regimens under conditions of temperate environment and moderate physical work.

b. To provide comprehensive baselines upon which to base future conclusive field studies which would incorporate the variables of extremes of heat and cold, hard physical work and the stresses of a survival situation.

3. Incidental aims were to study the nutritional problems of recovery after a period of restriction, and to obtain insight into some of the nutritional properties of the 5-in-1 ration when used for protracted periods.

B. Methods Of Study

1. To establish physiological, biochemical, nutritional, and clinical judgments on the relative effects of water intake, caloric intake and the ratio of protein, carbohydrate, and fat in the survival ration, numerous observations were made in recurring periods of adequate, restricted and recovery diets, with luxus amounts of vitamins at all times.

2. In the design of the experiment, three kinds of statistical controls were employed:

a. Starvation and a 3000 Calorie adequate ration represented the worst and best regimens. These were designated as "negative control" and "positive control", respectively.

b. Each subject was considered his own control with respect to changes in pre-periods, experimental periods and recovery periods.

c. Paired controls were planned for every experimental period, in that for each nutrient combination one subject received unlimited amounts of water and another was restricted to 900 ml of fluids per day.

STAT
STAT

3. Twenty nutrient combinations included the variables:
   a. Calories - 0, 1000, 2000 and 3000 per day.
   b. Water - unrestricted and limited to 900 ml of fluid per day.
   c. Distribution of calories - 0, 2, 15 and 30% from protein; 0, 20, 52 and 100% from carbohydrate; and 0, 33, 70 and 78% from fat.

4. The actual diets that were used were prepared from components of USAF rations, packets, experimental items and commercial items.
   a. Pre-periods, positive control, recovery periods: basically 5-in-1, but in recovery periods supplements of fresh bread, oleomargarine, ice cream, and orange juice were provided.
   b. 30/0/70: meat bar; high protein, high fat.
   c. 15/52/33: meat bar and cereal biscuit from the Ration, Special Survival; "normal mixture"; protein, carbohydrate and fat in average proportions.
   d. 2/20/78: chocolate bar or oleomargarine and soda crackers; high fat.
   e. 0/100/0: candy components of the SP Ration; pure carbohydrate.

5. In the actual scheduling, subjects subsisted for one week on a pre-period diet, two weeks on the experimental regimen and one week on recovery diet. This cycle was repeated five times in twenty-one weeks. During this entire period, the subjects were under close medical supervision. Continuous quantitative collections were made of urine and feces; and complete dietary records were kept of food and fluid consumption. At regular intervals specimens of venous blood were drawn for analysis, and the subjects were subjected periodically to special biochemical, physiological and clinical tests.

6. All methodology was validated statistically. For the most part standard accepted methods were used, but in some areas new methods had to be devised.

C. Results Of Study

1. In general, the biochemical and physiological results could be classified according to their pertinence in elucidating the problem of survival rations. Criteria of pertinence included the concepts that the measurement should be predictive of potential deterioration, should discriminate among nutrient combinations tested, and should be interpretable in terms of current clinical thought.

2. Nineteen radically different kinds of measurements proved to be valid for rank-ordering the 20 different nutrient combinations in terms of their protection against possible deterioration with respect to efficiency of the body as a whole and the functioning of organs. The 19 may be categorized as follows:

   a. Nutrient balances - calorie; water; nitrogen; sodium; potassium; phosphorus; acid-base (as measured by urinary excretion of acetone bodies).
   b. Body composition - change in body weight; change in body water.
   c. Liver function - serum cholinesterase.
   d. Kidney function - creatinine clearance; mean volume of daily urine; osmolar clearance as related to the urine/serum osmolar ratio; formed elements in the urine (Addis count).
   e. Endocrine function - urinary excretion of neutral 17-ketosteroids (adrenal cortex); blood sugar (pancreas); resting metabolism (thyroid).
   f. Hematology - red cell sedimentation rate (a clinical measure of response to some kinds of noxious stimuli).

3. Many other measurements were made, but not used, in arriving at the final judgments on the relative merits of the 20 nutrient combinations. Either the measurements showed no differences among nutrient combinations, or they did show differences which are not interpretable at present in terms of "survival potential". They may be categorized as follows:
   a. Nutrient balances - calcium; chloride (same as sodium).
   b. Body composition - body fat; lean body mass.
   c. Liver function - urobilinogen; cephalin flocculation; serum cholesterol.
   d. Kidney function - urinary specific gravity and total solids; serum urea nitrogen; urinary ammonia.
   e. Gastrointestinal function - characteristics of feces; fecal fat and fat absorption; qualitative examination of feces.
   f. Respiratory function - pulmonary ventilation; respiratory quotient; net oxygen consumption during physical work.
   g. Cardiovascular function - pulse rate, blood pressure, circulation time; electrocardiogram.
   h. Nervous system - reaction time; reflex time; psychological tests; electroencephalogram.
   i. Endocrine function - exocrine function of pancreas; serum calcium and phosphorus; urinary creatine; serum sodium; potassium; and chloride.
   j. Hematology - red blood cell count; hemoglobin; hematocrit; total white cell count; direct eosinophil count; thrombocytes; differential leukocyte count; erythrocyte indices; total serum protein.

4. Systematic daily clinical records were kept and periodic complete physical examinations were made by a medical officer experienced in clinical nutrition. In the final judgment concerning the relative merits of the 20 nutrient

combinations, clinical considerations were given substantial weight, for it is well known that clinically detectable deterioration may precede abnormal changes in physiological, biochemical or nutritional measurements, and that the clinical severity of a syndrome may not be correlated with the degree of abnormality of those measurements. Two major clinical findings are reported in detail.

a. Four clinical episodes occurred in the five phases that were of sufficient gravity to necessitate alteration of the regimen or transfer immediately to the recovery regimen. All four were associated with water deprivation.

b. Consistent symptoms occurred in relation to some of the nutrient combinations, and these symptoms were aggravated by water deprivation. The symptoms were chiefly referable to the gastrointestinal tract, and were present during subsistence on the chocolate bar, the meat bar, and the meat bar-cereal biscuit combination.

D. Specific Conclusions From Study

1. No nutrient combination, with or without limitation of water, scored as high as the adequate 3000 Calorie positive control, or as low as starvation.

2. No nutrient combination at 1000 Cal per day ranked as high as the same combination at 2000 Cal per day, water being unrestricted.

3. Restriction of water worsened the score of every nutrient combination, including starvation, with the sole exception of the high-protein-high fat regimen at 2000 Cal per day.

4. Although every nutrient combination possessed definite defects, when judged finally upon biochemical, physiological, nutritional grounds, as well as clinical, the combination that stood next to the adequate 3000-Calorie control ration was the "normal mixture" at 2000 Calories without restriction of water. Of the 1000 Calorie combinations, the least deleterious was also the "normal mixture."

5. Technological improvements are possible in several of the components used in the various nutrient combinations in order to obviate some of the clinical symptoms which developed during the several experimental regimens. For example, in the "normal mixture" gastrointestinal symptoms were present until the cereal biscuit was replaced by soda crackers, jam and canned fruit, the distribution of calories remaining constant; then the symptoms all disappeared.

E. General Conclusions

1. On the basis of past military and civilian experience, and the present studies, it must be concluded that the "survival

potential" of a castaway, from the nutritional point of view, is best maintained by a liberal intake of water and calories, and a ration that provides in acceptable form a distribution of calories approximating 15% from protein, 52% from carbohydrate and 33% from fat. In addition, all known vitamins should be provided in luxus amounts.

2. Important unsolved problems remain which can be solved only by comprehensive field and hospital studies with emphasis on the efficiency of the body as a whole and the functioning of organs and organ systems. Foremost among these are:

a. What is the effect of extreme heat and extreme cold?

b. What is the effect of muscular exertion required in escape and evasion?

c. What are the nutritional requirements of an injured castaway?

BIBLIOGRAPHY

Addis, T.: Clinical classification of Bright's diseases. J. Am. Med. Assoc., 85:163-167 (July 18) 1925.

Addis, T., Barrett, E., Poo, L. J., Ureen, H. J., and Lippman, R.W.: The relation between protein consumption and diurnal variations of the endogenous creatinine clearance in normal individuals. J. Clin. Invest., 30:206-209 (Feb.) 1951.

Albritton, E. C., editor: Standard Values in Blood. AF Technical Report No. 6039. Wright Air Development Center, Wright-Patterson Air Force Base, Dayton. (July) 1951.

Amundsen, R.: The Northwest Passage. 2 Vols. Constable, London, 1908. Vol. 2, p. 298.

Amundsen, R.: The South Pole. 2 Vols. John Murray, London, 1913. Vol. 1, pp. 54-55 and 88-89; Vol. 2, pp. 18, 36-37.

Andrews, J. S., and Oliver-Gonzáles, J.: The quantitative determination of blood in human feces. J. Lab. and Clin. Med., 27:1212-1217 (June) 1942.

Best, W. R.: An Improved Caliper for Measurement of Skinfold Thickness. Army Medical Nutrition Laboratory Report 113. Chicago (Aug. 31) 1953.

Best, W. R., and Kuhl, W. J.: Estimation of active protoplasmic mass by physical and roentgenological anthropometry. Army Medical Nutrition Laboratory, Report 114. Chicago (Sept. 5) 1953.

Best, W. R., and Samter, M.: Variations and error in eosinophil count of blood and bone marrow. Blood, 6:61-73 (Jan.) 1951.

Bills, C. E., McDonald, F. G., Niedermeier, W., and Schwartz, M. C.: Sodium and potassium in foods and waters. Determination by the flame photometer. J. Am. Dietet. Assoc., 25:304-314 (Apr.) 1949.

Blegen, E., Haugen, H. N., and Aas, K.: Endogenous "creatinine" clearance. Scand. J. Clin. Lab. Invest., 1:191-200, 1949.

Bonsnes, R. W., and Taussky, H. H.: On the colorimetric determination of creatinine by the Jaffé reaction. J. Biol. Chem., 158:581-591 (May) 1945.

Brod, J., and Sirota, J. H.: The renal clearance of endogenous "creatinine" in man. J. Clin. Invest., 27:645-654 (Sept.) 1948.

Brodie, B. B., Axelrod, J., Soberman, R., and Levy, B. B.: The estimation of antipyrine in biological materials. J. Biol. Chem., 179:25-29 (May) 1949.

Brodsky, W. A., Papoport, S., Granbarth, H. N., and Levkoff, A. H.: Osmotic diuresis as a measurement of renal function in man. J. App. Physiol., 5:62-72 (Aug.) 1952.

Brody, S.: Bioenergetics and Growth. Reinhold Publishing Corp., N. Y., 1945. pp. xii, 1023.

Brozek, J.: Changes of body composition in man during maturity and their nutritional implications. Fed. Proc., 11:784-793 (Sept.) 1952.

Brozek, J., and Keys, A.: Evaluation of leanness-fatness in man: a survey of methods. Nutr. Abst. Rev., 20:247-256 (Oct.) 1950.

Brozek, J., and Keys, A.: The evaluation of leanness-fatness in man: norms and interrelationships. Brit. J. Nutr., 5:194-206 (1951).

Brozek, J., and Tickelson, O.: Diet. In Human Factors in Undersea Warfare. Nat'l Research Council, Washington, 1949. pp. 311-328.

Calcagno, P. W., and Rubin, M. I.: Effect of dehydration produced by water deprivation, diarrhea and vomiting on renal function in infants. Pediat., 7:328-340 (Mar.) 1951.

Camara, A. A., Arn, K. D., Reimer, A., and Newburgh, L.H.: The twenty-four hourly endogenous creatinine clearance as a clinical measure of the functional state of the kidneys. J. Lab. and Clin. Med., 37:743-763 (May) 1951.

Cardoza, R. H., and Edelman, I. S.: The volume of distribution of sodium thiosulfate as a measure of the extracellular fluid space. J. Clin. Invest., 31:280-290 (Mar.) 1952.

Chasis, H., Goldring, W., Bread, E. S., Schreimer, G. S., and Bolomey, A. A.: Salt and protein restriction. J. Am. Med. Assoc., 142:711-715 (Mar. 11) 1950.

Clark, G. W.: Studies in the mineral metabolism of adult man. U. of Calif. Publ. in Physiol., 5:195-287 (June 19) 1926.

Conn, J. W.: The diagnosis and management of spontaneous hypoglycemia. J. Am. Med. Assoc., 134:130-137 (May 10) 1947.

Consolazio, C. F., Johnson, R. E., and Marek, E.: Metabolic Methods. C. V. Mosby, St. Louis, 1951.

Duncan, G. G.: Diseases of Metabolism. 2nd ed. W. B. Saunders Co., Philadelphia, 1947. pp. 258-259.

Edelman, I. S., Olney, J. M., James, A. H., Brooks, L., and Moore, F. D.: Body composition: Studies in the human being by the dilution principle. Science, 115:447-454 (Apr. 25) 1952.

Evans, C. L.: Principles of Human Physiology. 10th Ed. Lea and Febiger, Philadelphia, 1949. p. 319.

Fisher, P.: The role of ketone bodies in the etiology of diabetic coma. Am. J. Med. Sci., 221:384-397 (Apr.) 1951.

Fister, H. J.: Standard Procedures for Spectrophotometric Chemistry. Standard Scientific Supply Corp., N. Y., 1950.

Folin, O.: Two revised copper methods for blood sugar determination. J. Biol. Chem., 82:83-93 (April) 1929.

Folin, O., and Wu, H.: A system of blood analysis. J. Biol. Chem., 38:81-110. (May) 1919.

Galeotti, G.: Wassergehalt und Temperatur der ausgeatmeten Luft. Pflüger's Arch., 160:27-41 (Dec. 21) 1914.

Gamble, J.: Physiological information gained from studies on the life raft ration. Harvey Lectures, 42:247-273 (1947).

Glickman, N., Keeton, R. W., Mitchell, H. H., and Fahnestock, M. K.: The tolerance of man to cold as affected by dietary modifications: High versus low intake of certain water-soluble vitamins. Am. J. Physiol., 146:538-558 (July) 1946.

Greenberg, D. M.: The dynamics of calcium and phosphate metabolism. U. of Calif. Publ. in Physiol.: 8:277-292 (July 22) 1947.

Guilford, J. P.: Psychometric Methods. McGraw-Hill Co., N. Y., 1936.

Hall, T. H., editor: A Syllabus of Laboratory Examinations in Clinical Diagnosis. Harvard U. Press, Cambridge, Mass., 1952, pp. xiv, 496.

Hardy, J. D., and Drabkin, D. L.: Measurement of body water. Techniques and practical applications. J. Am. Med. Assoc., 149:1113-1116 (July 19) 1952.

Hartman, F. A., and Brownell, K. A.: The Adrenal Gland. Lea and Febiger, Philadelphia, 1949.

Haser, F. and Vogel, J.: Über den Werth der Traube'scher Formel. Archiv. für wissenschaftliche Heilkunde, 1:267-270, 1854.

Haugen, H. N.: The determination of endogenous "creatinine" in plasma and urine. Scand. J. Clin. and Lab. Invest., 5:48-57, 1953.

Haugen, H. N., and Blegen, E. M.: Blood urea and plasma endogenous "creatinine" in renal insufficiency. Scand. J. Clin. and Lab. Invest., 5:63-66, 1953a.

Haugen, H. N., and Blegen, E. M.: The true endogenous creatinine clearance. Scand. J. Clin. and Lab. Invest., 5:67-71, 1953b.

Hawk, P. B., Oser, B. L., and Summerson, W. H.: Practical Physiological Chemistry. 12th Ed. Blakiston Co., N. Y., 1951. pp. xiv, 1323.

Henderson, L. J., and Palmer, W. W.: On renal factors of acid excretion. J. Biol. Chem., 17:305-315 (Apr.) 1914.

Hepler, O. E.: Manual of Clinical Laboratory Methods. C. C. Thomas, Springfield, 1949.

Hoagland, H.: The physiological control of judgments of duration: evidence for a chemical clock. J. Gen. Psychol., 9:267-287, 1933.

Hoagland, H.: Pacemakers in Relation to Aspects of Behavior. The Macmillan Co., N. Y., 1935. pp. 107-120.

Hoagland, H., and Perkins, C. T.: Some temperature characteristics in man. J. Gen. Physiol., 18:399-408 (Jan. 20) 1935.

Hoeburger, F., Bonner, C. D., and Fishman, W. H.: Questionable significance of the ratios of phosphorus, nitrogen, and sulfur with reference to metabolic studies in man. Metabolism, 5:435-457 (Sept.) 1952.

Hurst, W. W., Scherm, F. R., and Vogel, W. C.: Simultaneous determination of total body water by antipyrine and deuterium oxide; evaluation of the methods on edematous subjects. J. Lab. and Clin. Med., 39:36-40 (Jan.) 1952.

Ivy, A. C., and Sandblom, P.: Biliary dyskinesia. Ann. Int. Med., 8:115-122 (Aug.) 1934.

Jeghers, H., and Bakst, H. J.: The syndrome of extrarenal azotemia. Ann. Int. Med., 11:1861-1899 (April) 1938.

Johnson, R. E., and Kark, R. M.: Feeding Problems in Man as Related to Environment. An Analysis of United States and Canadian Army Ration Trials and Surveys, 1941-1946. Research Reports. Q.M. Food and Container Institute, Chicago, 1947.

Josephson, R., and Dahlberg, G.: Variations in the cell-content and chemical composition of the human blood due to age, sex, and season. Scand. J. Clin. and Lab. Invest., 4:216-236, 1952.

van de Kamar, J. H., Huinink, T. B., and Weyers, H. A.: Rapid method for the determination of fat in feces. J. Biol. Chem., 177:347-355 (Jan.) 1949.

Katz, L. N.: Electrocardiography. 2nd ed. Lea and Febiger, Philadelphia, 1946. p. 125.

Keeton, R. W., Lambert, E. H., Glickman, N., Mitchell, H. H., Last, J. H., and Fahnestock, M. K.: The tolerance of man to cold as affected by dietary modifications: Proteins versus carbohydrates, and the effect of variable protective clothing. Am. J. Physiol., 146:66-83 (Apr.) 1946.

Keys, A.: Obesity measurement and the composition of the body. In Overeating, Overweight and Obesity (R. S. Goodhart, ed.). Nutrition Symposium Series No. 6. National Vitamin Foundation, N. Y. (Jan.) 1953. pp. 13-35.

Keys, A.: The Biology of Human Starvation. Vols. I and II. U. of Minn. Press, Minneapolis, 1950.

Keys, A., and Brozek, J.: Body fat in adult man. Physiol. Rev., 33:245-325 (July) 1953.

Kingsley, G. R.: The direct biuret method for the determination of serum proteins as applied to photoelectric and visual colorimetry. J. Lab. and Clin. Med., 27:840-845 (Mar.) 1942.

Kingsley, G. R., and Schaffert, R. R.: Determination of free and total cholesterol by direct chloroform extraction. J. Biol. Chem., 180:315-328 (Aug.) 1949.

Kleitman, N.: Biological rhythms and cycles. Physiol. Rev., 29:1-30 (Jan.) 1949.

Kleiner, I. S.: Human Biochemistry. C. V. Mosby Co., St. Louis, 1945. p. 409.

Kline, R. F., and Dyme, H. C.: Relation of food to survival potential at high temperature of animals restricted isocalorically. Fed. Proc., 12:77 (Mar.) 1953.

Kowalski, H. J., and Rutstein, D. D.: The distribution of the thiosulfate ion with respect to normal human serum and red blood cells and its application to "extracellular fluid" determination. J. Clin. Invest., 31:370-374 (Apr.) 1952.

Krocko, R. R.: Color Atlas of Hematology. J. B. Lippincott Co., Philadelphia, 1947.

Landon, R. L., Knowlton, Kathryn, Anderson, Dolores, Granit, Minnie R., and Kenyon, A. T.: The effect of starvation on urinary 17-Ketosteroid excretion. J. Clin. Endocrinol., 8:138-145 (Feb.) 1948.

Lange, K., and Boyd, L. J.: The use of fluorescein to determine the adequacy of the circulation. Med. Clin. North America, 26:943-952 (May) 1942.

Lipman, R. W.: Urine and the urinary sediment. A practical manual and atlas. C. C. Thomas Co., Springfield, 1952. pp. xii, 124.

Lusk, G.: The Elements of the Science of Nutrition. 4th Ed. W. B. Saunders Co., Philadelphia, 1928. 844 p.

Maclagan, N. F.: Recent developments in flocculation tests. In Liver Disease (S. Sherlock and J. E. W. Wolstenholme, ed.), J. A. Churchill, Ltd., 1951. pp. 1-6.

Malloy, H. T., and Evelyn, K. A.: The determination of bilirubin with the photoelectric colorimeter. J. Biol. Chem., 119:481-490 (July) 1937.

Mandel, E. E., and Jones, F. L.: Studies in non-protein nitrogen. III. Evaluation of methods measuring creatinine. J. Lab. and Clin. Med., 41:323-334 (Feb.) 1953.

McCance, R. A., and Widdowson, E. M.: The secretion of urine in man during experimental salt deficiency. J. Physiol., 91: 222-231 (Nov. 26) 1937.

Mendeloff, A. I.: Selection of a screening procedure for detecting occult blood in feces. J. Am. Med. Assoc., 152:798-804 (June 27) 1953.

Miller, Erma O., Nickolson, O., and Keys, A.: Urinary excretion of 17-Ketosteroids by normal young men during starvation. Proc. Soc. Exper. Biol. and Med., 67:288-292 (Mar.) 1948.

Mitchell, H. H., Glickman, N., Lambert, E. H., Keeton, R. W., and Fahnestock, M. K.: The tolerance of man to cold as affected by dietary modification: carbohydrate versus fat and the effect of frequency of meals. Am. J. Physiol., 146: 76-96 (Apr.) 1946.

Myerson, A.: Human autonomic pharmacology. XII. Theories and results of autonomic drug administration. J. Am. Med. Assoc., 110:101-103 (Jan. 8) 1938.

STAT
STAT

Newburgh, L. H., editor: Physiology of Heat Regulation and the Science of Clothing. W. B. Saunders Co., Philadelphia, 1949. pp. viii, 457.

Newburgh, L. H., and Johnston, M. W.: The insensible loss of water. Physiol. Rev., 22:1-18 (Jan.) 1942.

Newburgh, L. H., Johnston, M. W., and Newburgh, J. D.: Some fundamental principles of metabolism. 3rd Ed. J. W. Edwards, Ann Arbor, 1948. 70 p.

Newman, C.: Physiology of the gall-bladder and its functional abnormalities. Lancet, 224:735-791 (Apr. 15); 840-848 (Apr. 22); 896-902 (Apr. 29) 1933.

Nutrition Reviews: Serum cholinesterase and nutritional status. Nutr. Rev., 10:352 (Nov.) 1952.

Osgood, C. E.: The nature and measurement of meaning. Psychol. Bull., 49:197-237

Pace, N., and Rathburn, E.N.: Studies on body composition. III. The body water and chemically combined nitrogen content in relation to fat content. J. Biol. Chem., 158:685-691 (May) 1945.

Peary, R. E.: The North Pole. 2nd Ed. F. A. Stokes Co., N. Y., 1910. pp. 25 and 210.

Peters, J. H.: The determination of creatinine and creatine in blood and urine with the photoelectric colorimeter. J. Biol. Chem., 146:179-186 (Nov.) 1942.

Peters, J. P., and Van Slyke, D. D.: Quantitative Clinical Chemistry. Interpretations, Vol. I. 2nd Ed. Williams and Wilkins Co.; Baltimore, 1946.

Pinson, E. A.: Water exchange and barriers as studied by the use of hydrogen isotopes. Physiol. Rev., 32:123-134 (Apr.) 1952.

Pitesky, I., and Last, J. H.: Effects of seasonal heat stress on glomerular and tubular functions in dog. Am. J. Physiol., 164:497-501 (Feb.) 1951.

Popper, H.: Discussion: Factors affecting the results of flocculation tests. In Liver Disease (S. Sherlock and G. E. W. Wolstenholme, ed.). J. A. Churchill, Ltd., 1951. pp. 8-10.

Price, J. W., Miller, M., and Hayman, J. M., Jr.: The relation of specific gravity to composition and total solids in normal human urine J. Clin. Invest., 19:537-554 (May) 1940.

Pullen, R. L.: Medical Diagnosis. W. B. Saunders Co., Philadelphia, 1944.

Quinn, M., Kleeman, C. R., Bass, D. E., and Henschel, A.: Metabolic comparison of protein and protein-free diets during restricted caloric and water intake. Office of Quartermaster General, Environmental Protection Branch Report No. 201. March, 1953a.

Quinn, M., Kleeman, C. R., Bass, D. E., and Henschel, A.: Further study of survival rations with adequate water intake. Office of Quartermaster General, Environmental Protection Branch Report No. 205. March, 1953b.

Raab, W.: The pathogenic significance of adrenaline and related substances in the heart muscle. Exper. Med. Surg., 1:188-225, 1943.

Rapoport, S., Brosky, W. A., and West, C. D.: Excretion of solutes and osmotic work of the "frosting" kidney of hydropenic man. Am. J. Physiol., 157:357-362 (June) 1949.

Rapoport, S., Brodsky, W. A., West, C. D., and Hackler, B.: Urinary flow and excretion of solutes during osmotic diuresis in hydropenic man. Am. J. Physiol., 156:433-442 (Mar.) 1949.

Reifenstein, E. C., Jr., Albright, F., and Wells, S. L.: The accumulation, interpretation, and presentation of data pertaining to metabolic balances, notably those of calcium, phosphorus, and nitrogen. J. Clin. Endocrinol., 5:367-395 (Nov.) 1945.

Rider, P. R.: An Introduction to Modern Statistical Methods. John Wiley and Sons, Inc., N. Y., 1939.

Roth, J. L. D.: The physiological requirements for survival rations. AF Technical Report 5740. Air Material Command, Wright-Patterson Air Force Base, Dayton, Ohio, 1948.

Sargent, F. II.: A critique of homeostasis: season and metabolism. Arch. f. Meteorol. Geophys. u. Bioklimatol., Serie B, 3:389-396 (1951).

Sargent, F. II., and McArthur, E. M.: A Critical Review of Quantitative Methods for Determining Ketone Bodies in Biological Fluids. WADC Technical Report 53-335. Wright Air Development Center, Ohio (Feb.) 1953.

Sayers, G.: The adrenal cortex and homeostasis. Physiol. Rev. 30:241-320 (July) 1950.

Schloerb, P. L., Friis-Hansen, B. J., Edelman, I. S., Solomon, A. K., and Moore, F. D.: The measurement of total body water in human subjects by deuterium oxide dilution: with consideration of dynamics of deuterium distribution. J. Clin. Invest., 29:1296-1310 (Oct.) 1950.

Schoch, H. K., and Cámara, A. A.: Endogenous creatinine clearance. In Methods in Medical Research (A. C. Corcoran, ed.), Vol. 5. pp. 214-219. Year Book Publishers, Inc., Chicago, 1952.

Schoenberger, J. A., Rix, D. M., Sakamoto, A., Taylor, J. D., and Kark, R. M.: Metabolic effects, toxicity and excretion of calcium n-cyclohexylsulfamate (sucaryl) in man. Am. J. Med. Sci., 225:551-559 (May) 1953.

Schwimmer, D., and McGavack, T. H.: Protein metabolism on reduced caloric and water intakes. Q. M. Food and Container Institute; Report No. 5, August, 1948.

Schwimmer, D., McGavack, T. H., Boyd, L. J., and Rubin, S. H.: Protein metabolism at low caloric intakes. Q. M. Food and Container Institute. Progress Reports Nos. 1, 2, and 3. Nov. 1952, Jan., 1953 and April, 1953.

Selye, Hans: The general adaptation syndrome and the diseases of adaptation. J. Clin. Endocrinol., 6:117-230 (Feb.) 1946.

Shapiro, S., and Weiner, M.: Coagulation, Thrombosis, and Dicumarol. Brooklyn Medical Press, N. Y., 1949. pp. 21-24.

Shapiro, S., Weiner, M., Luddecke, H. F., Knoc, R. L., and White, E. J.: A simply prepared, standardized and relatively stable thromboplastin extract for estimation of prothrombin time. Am. Heart J., 40:766-770 (Nov.) 1950.

Sheldon, W. H.: The Varieties of Human Physique. Harper and Bros., N. Y., 1940.

Sherlock, S., and Wolatenholme, G. E. W.: Liver Disease. Ciba Foundation Symposium. J. & A. Churchill Ltd., 1951. pp. xiv, 249.

Sherman, H. C.: The Chemistry of Food and Nutrition. 6th ed. The Macmillian Co., N. Y., 1941.

Smith, D. A., and Woodruff, M. F. A.: Deficiency diseases in Japanese prison camps. Med. Res. Council, Spec. Report Series, No. 274, 1951.

Smith, H. W.: The Kidney. Structure and Function in Health and Disease. Oxford University Press, N. Y., 1951. pp. xxii 1049.

Smith, H. W.: Renal excretion of sodium and water. Fed. Proc., 11:701-714 (Sept.) 1952.

Soberman, R., Brodie, B. B., Levy, B. B., Axelrod, J., Hollander, V., and Steele, J. M.: The use of antipyrine in the measurement of total body water in man. J. Biol. Chem., 179:31-42 (May) 1949.

Solomon, A. K., Edelman, I. S., and Soloway, S.: The use of the mass spectrometer to measure deuterium in body fluids. J. Clin. Invest., 29:1311-1319 (Oct.) 1950.

Somogyi, M.: A method for the preparation of blood filtrates for the determination of sugar. J. Biol. Chem., 86:655-663 (Apr.) 1930.

Stefansson, V.: Not By Bread Alone. The Macmillan Co., N. Y., 1948.

Steinitz, K., and Turkand, H.: The determination of the glomerular filtration by the endogenous creatinine clearance. J. Clin. Invest., 19:285-298 (Mar.) 1940.

Taylor, A. E.: On the cutaneous elimination of nitrogen, sulfur, and phosphorus. J. Biol. Chem., 9:21-24, 1911.

Todd, J. C., and Sanford, A. H.: Clinical Diagnosis by Laboratory Methods. 11th Ed. W. B. Saunders Co., Philadelphia, 1948.

Toscani, V., and Whedon, G. D.: Nitrogen loss in the feces: the variability of excretion in normal subjects on constant dietary intakes. J. Nutrition, 45:117-130 (Sept.) 1951.

Vorhaus, L. J., and Kark, R. M.: Serum cholinesterase in health and disease. Am. J. Med., 14:707-719 (June) 1953.

Weber, A. O.: Estimation of time. Psychol. Bull., 30:233-252 (Mar.) 1933.

Wenger, M. A.: A study of physiological factors: the autonomic nervous system and the skeletal musculature. Human Biol., 14:69-83 (Feb.) 1942.

Wenger, M. A.: An attempt to appraise individual differences in level of muscular tension. J. Exper. Psychol., 32:213-225 (Mar.) 1943a.

Wenger, M. A.: A further note on the measurement of autonomic balance. Psychosomatic Med., 5:148-151 (Apr.) 1943b.

Wenger, M. A.: Seasonal variations in some physiological variables. J. Lab. and Clin. Med., 28:1101-1108 (June) 1943c.

STAT
STAT

Wenger, M. A., and Ellington, M.: The measurement of autonomic balance in children: method and normative data. Psychosomatic Med., 5:241-253 (July) 1943.

Wintrobe, M. M.: Clinical Hematology. 2nd Ed. Lea and Febiger, Philadelphia, 1946. 862 p.

Woirsio, J. H., and Winter, G. D.: Statistical analysis of human red blood cell and plasma cholinesterase activity values. Arch. Indus. Hyg. and Occup. Med., 6:43-49 (July) 1952.

INDEX OF TABLES IN APPENDICES

INDEX OF TABLES IN APPENDICES (contd)

INDEX OF TABLES IN APPENDICES (contd)

APPENDIX I

METHODS: TABLE OF CONTENTS

A. DETERMINATION OF SERUM ANTIPYRINE

References: Brodie, B. B., et al. The Estimation of Antipyrine in Biological Fluids. J. Biol. Chem., 179:789-29 (May) 1949; Soberman, R., et al. The Use of Antipyrine in the Measurement of Total Body Water in Man. J. Biol. Chem., 179:31-42 (May) 1949.

Principle: The optical density of a protein-free centrifugate containing antipyrine is determined spectrophotometrically at 350 mμ. The antipyrine is destroyed by the addition of $NaNO_2$ and the optical density of the centrifugate is remeasured. The difference between initial and final optical densities is proportional to the concentration of antipyrine.

Reagents:

1. Zinc reagent: 1 gram of $ZnSO_4 \cdot 7 H_2O$ and 10 ml of 6 N H_2SO_4. The zinc sulfate is dissolved in the acid and the reagent solution diluted to one liter.
2. 0.75 N NaOH.
3. 4.0 N H_2SO_4.
4. 0.2% $NaNO_2$.

Apparatus:

1. Volumetric flasks.
2. Volumetric pipettes.
3. Beckman Model B spectrophotometer.

Procedure:

1. The following are added to a 50 ml Erlenmeyer flask in order: 2.0 ml of serum, 20 ml of distilled water, 2.0 ml of zinc reagent, and 2.0 ml of 0.75 N NaOH. The latter is added drop by drop with constant mixing.
2. Precipitation is allowed to continue for 10 minutes; after which the solution is transferred to a centrifuge tube and centrifuged at 3500 rpm for 15 minutes.
3. Transfer 3.0 ml of centrifugate to a cuvette.
4. Add 1 drop of 4 N H_2SO_4.
5. Measure optical density at 350 mμ. The spectrophotometer is zero-set with a blank prepared by adding one drop of 4 N H_2SO_4 to 3.0 ml of distilled water. This is reading R_1.
6. Add two drops of 0.2% $NaNO_2$ to both blank and unknown and after 20 minutes read unknown after zero-setting instrument with blank. This is R_2.
7. The concentration of antipyrine per ml of serum is determined from a standard curve using R_1-R_2 to locate the optical density.
8. The concentration of antipyrine per ml of serum water is determined by the following formula:

$$\text{mcg/ml serum water} = \frac{(\text{mcg/ml serum}) \times (1.0 \text{ ml serum})}{(\text{Gm}\%\text{ serum protein}/100 \text{ ml})}$$

The concentration of serum protein is measured by the falling drop method (Consolazio, Johnson, and Marek, 1951).

Standardization:

1. The stock standard is prepared as follows: 100 mg of antipyrine crystals are accurately weighed out and diluted in a volumetric flask to 1000 ml. Each ml of this solution therefore contains 0.1 mg antipyrine.
2. From the stock standard solution prepare solutions containing 2.5, 5.0, 7.5, 10, 15, and 20 mcg/ml.
3. Duplicate 1.0 ml aliquots of each of these solutions are treated according to steps 1-6 of Procedure above.
4. A plot is made of optical density (R_1-R_2) against concentration (mcg/ml).

B. DETERMINATION OF TOTAL NEUTRAL 17-KETOSTEROIDS IN URINE

References: Drekter, I., Drekter, A., Scism, G., Stern, S., Pearson, S., and McCavack, T. The Determination of Urinary Steroids I. The Preparation of a Pigment-Free Extract and a Simplified Procedure for the Estimation of Total 17-Ketosteroids. J. Clin. Endocrinol. and Metab., 12:55-65 (Nov.) 1952. Holtorff, A. F. and Koch, F. C. The Colorimetric Estimation of 17-Ketosteroids and their Application to Urine Extracts. J. Biol. Chem., 132:377-398 (Sept.) 1940. Jensen, C. C. and Tobberman, L. E. Hydrolysis of Urinary Neutral 17-Ketosteroid Conjugates I. Comparison of Various Procedures. Acta Endocrinol., 10:221-232 (1952). Vestergaard, P. Rapid Micro-Modification of the Zimmerman-Callow Procedure for the Determination of 17-Ketosteroids in Urine. Acta Endocrinol., 8:193-214 (Nov.) 1951.

Principle: The 17-ketosteroids are extracted from urine into ether. The ether is dried and the residue is taken up in absolute alcohol. When reacted with m-dinitrobenzene a purple color develops the depth of which is measured spectrophotometrically at 520 mμ. The calibration standard is dehydroisoandrosterone.

Apparatus:

1. Test tube of 50-60 ml capacity.
2. Separatory funnel, pear shaped, 250 ml.
3. Erlenmeyer flasks of 125 ml capacity.
4. Pipettes of 2.0 ml and 20 ml capacity.
5. Water bath.
6. Vacuum desiccator.
7. Whatman No. 1 filter paper, 12.5 cm.
8. Funnel.

Reagents:

1. Ethyl ether: best available grade ether stored over KOH pellets. Distilled immediately before use.
2. Sodium hydroxide pellets.
3. Sodium sulfate.

4. Sulfuric acid, 70 vol.%.
5. m-Dinitrobenzene, 2% in absolute alcohol.
6. Standard solution of dehydroisoandrosterone, 0.1 mg/ml.

Procedure (Extraction of 17-Ketosteroids):

1. Into a test tube containing 1/100th of a 24 hr urine sample, add 1/10th volume of 70 vol.% sulfuric acid. Substitute distilled water for the method blank.
2. Place tube in a boiling water bath for 30 min.
3. Cool immediately with running water.
4. Transfer hydrolyzed material quantitatively to a separatory funnel.
5. Extract twice with ether (35 ml then 25 ml). Use the first 35 ml of ether to rinse out test tube. In order to extract twice, two separatory funnels will be needed. Shake ether-urine mixture 2 min each.
6. Combine ether extracts into one separatory funnel. Rinse out other funnel with 10 ml of ether. Combine with other extracts.
7. Add 5.0 ml of distilled water and shake for 1 min.
8. Discard aqueous layer.
9. Add a dash of sodium sulfate (for drying). Remove any water that may have settled.
10. Add 40-50 sodium hydroxide pellets to the ether extract and shake for 5 min.
11. Filter into an Erlenmeyer flask using Whatman No. 1 filter paper.
12. Wash funnel with 10 ml of ether. Filter into flask. Wash filter paper with 10 ml of ether.
13. Evaporate to dryness using suction.
14. After all ether vapors have been removed, dissolve residue in 1.0 ml of absolute ethanol. Swirl flask to insure complete solution of steroids.
15. Exactly 0.2 ml of this solution is used for the color reaction.

Procedure (Zimmerman Color Reaction):

1. Into a colorimetric tube pipette exactly 0.2 ml of an alcoholic solution of the steroids.
2. Add 0.2 ml of 2% m-dinitrobenzene.
3. Add 0.2 ml of 5 N KOH.
4. Prepare reagent blank by substituting 0.2 ml of absolute ethanol for the steroid solution.
5. Prepare a urine blank by substituting 0.2 ml of absolute ethanol for the m-dinitrobenzene solution.
6. Prepare a standard 0.2 ml of an alcoholic solution of dehydroisoandrosterone (0.1 mg/ml).
7. Incubate for 60 min. at 25.0 ± 0.5°C in the dark.
8. Remove from incubator and dilute with 10 ml of 95% ethanol. Invert tubes twice.
9. Set spectrophotometer at 100% transmission using ethanol blank at 520 mμ.
10. Read urine blank.
11. Read reagent blank. Reset to 100% transmission.
12. Read standard.
13. Read method blank. Reset to 100% transmission.

STAT

14. Read unknowns.
15. Repeat steps 9-14 using 420 mμ.
16. Use correction equation:

$$\frac{K_1\ (520) - (420)}{K_1 - K_s} = K$$

K = true reading at 420 mμ.
K_1 = ratio of interfering chromogens at 420 to 520 mμ.
K_s = ratio of pure steroid at 420 to 520 mμ.
In our laboratory K_1 is consistently 2.0 and K_s has been 0.51.

17. Calculate the mg of ketosteroid from a standard curve.

Precautions:

1. The stability of 17-ketosteroids in urine has been established. These substances are stable for at least three months under the conditions of storage used (Table AI. 1).

TABLE AI. 1

STABILITY OF URINARY 17-KETOSTEROIDS

Preservative = 2.0 ml Toluene per 2 liters Urine
Stored at 5°C

Values listed as mg 17-KS/24 hours

	March 15	April 30	June 29
	15.57	15.78	15.08
	15.08	15.57	15.01
Mean	15.32	15.67	15.04
S. E.	± 0.25	± 0.11	± 0.04
S. E. M.	± 0.25	± 0.11	± 0.04

C. EXTRACTION OF CORTICOID-LIKE MATERIAL FROM FECES

Principles:

Hydrolysis. Metabolites of adrenocortical hormones are known to be excreted in at least three forms: (1) in the free state; (2) as easily hydrolyzed conjugates; and (3) as conjugates that are hydrolyzed only after strong acid hydrolysis. The first form is extractable from aqueous solutions at neutral pH. The second is extractable after adjustment to pH 1. The third form as indicated is extracted only after heating in the presence of strong acid.

Extraction. The conjugated adrenocortical hormones are soluble in most organic solvents, but are most soluble in chloroform. In working with aqueous fecal suspensions, the use of chloroform was found to be inconvenient and 4:1 ether-chloroform was substituted. Several extractions with 4:1 ether-chloroform is as efficient in extracting adrenocortical metabolites as a single chloroform extraction.

Fractionation. A crude lipid extract may be divided into three fractions, designated as the neutral, acidic, and phenolic fractions (after Dobriner et al., 1942). The acidic fraction is that material which is extractable from the crude lipid extract by 5% (w/v) sodium bicarbonate. The phenolic fraction is that which is extractable by 5% sodium hydroxide; and that material which is left in the crude lipid extract is the neutral fraction.

Separation of Ketonic and Non-ketonic Materials. Ketonic materials form water-soluble derivatives with Girard's reagent T, by reacting in aqueous solution containing the hydrazone of the ketonic materials found in the lipid extract of feces with an organic solvent, the non-ketonic materials can be removed. Acidification of the aqueous solution results in the hydrolysis of the Girard T hydrazones, and the ketonic materials may be extracted with an organic solvent.

Color Reactions. The following tests are utilized in testing for and estimating adrenocortical-like materials in the feces of the human male. The first test was the Zimmermann reaction (Zimmermann, 1935, 1936) which under standardized conditions, is specific for steroids containing a keto group at the 17 position in the steroid nucleus. The second test was the so-called Porter-Silber (1950) reaction which utilizes the reaction of phenylhydrazine hydrochloride in 1.6:1 sulfuric acid with the steroid dissolved in methanol. The Porter-Silber reaction is reported to be specific of 17,21-dihydroxy-20-ketosteroids. The third was the Mader-Buck (1952) reaction in which blue tetrazolium was reduced to give an intense blue color by steroids containing an alpha-keto grouping (i.e., 21-hydroxy-20-ketosteroids). The fourth test was the Gornall reaction (Gornall and MacLeod, 1953), which is the reaction of 3,5-dinitrophenylhydrazine in methanolic hydrochloric acid with steroids with an alpha-beta unsaturated 3-keto grouping and/or a 17,21-dihydroxy-20-keto grouping. Other keto groupings will react with this reagent, but under the conditions of the test, the color developed by these other keto groupings is small in comparison to the above groupings.

Treatment and Extraction of Acidic Fecal Suspensions.

Apparatus:

1. 125 ml Pyrex reagent bottles with standard taper stoppers.
2. Two 10 ml syringes equipped with 3.5-4.5 inch 13-gage hypodermic needles.
3. Assorted beakers.
4. One 2 ml syringe pipette.
5. One 1 ml serological pipette calibrated in 0.1 ml.
6. International Centrifuge, size 1, type C.

Reagents:

1. Concentrated sulfuric acid, reagent grade.
2. 70 vol.% sulfuric acid.
3. Redistilled ether (boiling range 34-45°C).
4. Chloroform, reagent grade.
5. 4:1 ether-chloroform mixture.

Procedure:

1. 10 ml aliquots of aqueous fecal suspension transferred to 125 ml reagent bottles with a 10 ml syringe.
2. Add 10 ml distilled water.
3. Treat feces in one of the following three ways:
   a. no further treatment.
   b. adjust fecal suspension to pH 1 by adding 0.1 ml concentrated sulfuric acid and checking with pH paper.
   c. hydrolyze feces by adding 2 ml 70 vol.% sulfuric acid with a 2 ml syringe pipette and place bottles in a boiling water bath for 30 minutes. Cool bottles in running tap water.
4. Extract feces 4 times with 30, 25, 20 and 10 ml lots of 4:1 ether-chloroform. Shake each lot for 2 minutes and centrifuge for at least 2 minutes. If a solvent layer does not separate after centrifuging, agitate the emulsion slightly and recentrifuge.
5. Remove each lot of solvent with a syringe fitted with a 13-gage needle, taking as little of the aqueous phase as possible. The solvent is then transferred to a second 125 ml reagent bottle.

Preparation of Neutral, Acidic and Phenolic Fractions of Solvent Extract

Apparatus:

1. 10 ml syringe, fitted with a 3.5-4.5-inch, 13-gage needle.
2. 5 ml pipette calibrated in 0.1 ml.
3. 125 ml Erlenmeyer flasks.
4. 125 ml Pyrex reagent bottles.
5. International centrifuge, size 1, type C.
6. Vacuum desiccator.

Reagents:

1. 10% (W/V) sodium bicarbonate.
2. 2 N sodium hydroxide.
3. 2:1 sulfuric acid (one part concentrated acid to two parts water).
4. 4:1 ether-chloroform.

Procedure:

1. Extract the ether-chloroform extract of feces three times with 10 ml lots of 10% sodium bicarbonate. The bicarbonate solution is taken up in a 10 ml syringe and transferred to another 125 ml reagent bottle.

2. Backwash the combined bicarbonate extracts with 10 ml of ether-chloroform, adding the wash to the original feces extract.
3. Add 3 ml of 2:1 sulfuric acid to the bicarbonate extract.
4. Extract the bicarbonate solution with three 20 ml lots of ether-chloroform.
5. Wash the ether-chloroform extract of the bicarbonate solution once with 10 ml water, dry with anhydrous sodium sulfate, and transfer to 125 ml Erlenmeyer flasks.
6. Evaporate the ether-chloroform extract of the bicarbonate solution to dryness under reduced pressure in a vacuum desiccator and dry over anhydrous calcium chloride. The residue is defined as the acidic fraction.
7. Extract the original fecal extract in step 2 with three 10 ml lots of 2 N sodium hydroxide, shaking each lot for 2 minutes.
8. The combined NaOH extract is backwashed once with 10 ml of ether-chloroform, adding the wash to the original ether-chloroform extract of feces.
9. The original ether-chloroform extract can now be washed with water, dried with anhydrous sodium sulfate, transferred to 125 ml Erlenmeyer flasks and evaporated to dryness under reduced pressure in a vacuum desiccator. The residue represents the neutral fraction of the ether-chloroform extract of the feces.
10. The NaOH extract is acidified with 5 ml of 2:1 sulfuric acid and extracted three times with 20 ml lots of ether-chloroform shaking each lot for 2 minutes.
11. The ether-chloroform extracts of the NaOH solution are washed with water, dried by adding anhydrous sodium sulfate, transferred to 125 ml Erlenmeyer flasks, and evaporated to dryness under reduced pressure in a vacuum desiccator. The residue is defined as the phenolic fraction.

Separation of Ketonic and Non-Ketonic Materials

Apparatus:

1. 60 ml Pyrex reagent bottles with standard taper stoppers.
2. 0.5 ml syringe pipette.
3. 1 ml syringe pipette.
4. Two 10 ml syringes fitted with 13-gage needles.
5. Assorted beakers.
6. 125 ml Erlenmeyer flasks.
7. 50 ml Erlenmeyer flasks or beakers.
8. International Centrifuge, size 1, type C.
9. Vacuum desiccator.

Reagents:

1. Redistilled ether (boiling range 34-45°C).
2. Chloroform, reagent grade.
3. 4:1 ether-chloroform.
4. Glacial acetic acid.
5. 30% (W/V) sodium hydroxide.

6. 2:1 sulfuric acid.
7. Girard's reagent T stored over anhydrous calcium chloride.

Procedure:

1. Transfer samples or standards to 60 ml reagent bottles and evaporate to dryness under reduced pressure.
2. Dry samples over anhydrous calcium chloride for at least 24 hours.
3. Add 0.2 gm Girard T reagent and 0.5 ml glacial acetic acid.
4. Stopper bottles with aluminum foil and heat in a boiling water bath for 3 minutes with occasional rotation.
5. Chill in an ice bath and add 10 ml ice cold distilled water.
6. Add 1 ml 30% NaOH.
7. Extract the solution 3 times with 5 ml lots of cold ether, centrifuging each lot. Remove the ether layer to a second 60 ml bottle with a syringe equipped with a 13-gage needle.
8. Wash the combined ether lots three times with 5 ml distilled water and centrifuge, removing the aqueous phase to a 50 ml beaker or Erlenmeyer flask.
9. Add 1 ml 2:1 sulfuric acid to the combined water washings and add the washings to the original aqueous phase from step 7.
10. The aqueous phase now contains the ketonic material and the ether contains the non-ketonic material. For best results, steps 3 through 9 should be completed as rapidly as possible since the hydrazones formed hydrolyzes spontaneously at room temperature.
11. Add 8 ml of 4:1 ether-chloroform to the aqueous phase and let stand at room temperature for 2 hours. (Ether may be substituted for ether-chloroform if only 17-ketosteroids are to be determined.) Chloroform may be used instead of ether-chloroform if desired.
12. At the end of 2 hours, extract the aqueous phase with the solvent present and with three more 8 ml lots of ether-chloroform, centrifuging each lot. Shake each lot for 2 minutes.
13. Transfer the solvent extracts to 60 ml reagent bottles and wash twice with 3 ml lots of water, centrifuging each lot.
14. Dry the extract by adding anhydrous sodium sulfate and shaking.
15. Transfer the extract to 125 ml Erlenmeyer flasks and evaporate to dryness under reduced pressure in a vacuum desiccator. Dry residue over anhydrous calcium chloride.
16. Take up the residue in a known amount of 95% ethanol and save for chemical assay.

Determination of 17-Ketosteroids

Apparatus:

1. Colorimetric tubes, 19 x 105 mm.
2. Coleman Junior Spectrophotometer (Model 6B).
3. Pipettes, 0.2 ml and 10 ml capacity.

Reagents:

1. Absolute ethanol, redistilled.

2. 95% ethanol, redistilled.
3. m-Dinitrobenzene purified by heating in 10% aqueous NaOH until melted. Decant the alkali while hot. Allow the m-dinitrobenzene to cool, then wash twice with water. Add 95% ethanol and dissolve with heat (not above 50°C). Cool and add 5 volumes of water. Filter and wash precipitate twice with water. M. P. should be 90.0-91.0°C. Recrystallize if necessary. Prepare a 2% solution in absolute ethanol (Drekter et al., 1947).
4. Potassium hydroxide 5.0 N aqueous, prepared by dissolving 18 gm of KOH in 50 ml of distilled water. Check concentration by titrating against standard acid, using phenol red as indicator.
5. Standard solution of dehydroisoandrosterone in absolute ethanol (0.1 mg/ml).

Procedure:

1. Place aliquot of 95% ethanol solution (from Girard T separation) into a colorimetric tube and evaporate to dryness. Add 0.2 ml of absolute ethanol.
2. Add 0.2 ml of 2.0% m-dinitrobenzene.
3. Add 0.2 ml of 5 N KOH.
4. Prepare a reagent blank by substituting 0.2 ml of absolute ethanol for the steroid solution.
5. Prepare a fecal blank by substituting 0.2 ml of absolute ethanol for the m-dinitrobenzene solution.
6. Prepare a standard consisting of 0.2 ml of an alcoholic solution of dehydroisoandrosterone (0.1 mg/ml).
7. Incubate for 60 min at 25.0 ± 0.5°C in the dark.
8. Remove from incubator and dilute with 10 ml of 95% ethanol. Invert tubes twice.
9. Set spectrophotometer at 100% transmission using ethanol blank at 520 mμ.
10. Read fecal blank.
11. Read reagent blank. Reset to 100% transmission.
12. Read standard.
13. Read method blank. Reset to 100% transmission.
14. Read unknowns.
15. Repeat steps 9-14 using violet filter (420 mμ).
16. Unknowns are read from the standard curve and evaluated by multiplying by the proper dilution factors.

Example: unknown is equivalent to 20 mcg of crystalline steroid and represents 1/10 of a 10 ml aliquot of feces suspension (volume = 2000 ml)

$$\text{mg steroid/2000 ml} = \frac{(20)\ (10)\ (2000)}{(10)\ (1000)} = 40 \text{ mg}$$

(The above procedure for calculating mg of steroid in a given suspension is applicable to all color reactions described in this paper.)

STAT
STAT

Porter-Silber Reaction

Apparatus:

1. Coleman Junior Spectrophotometer (Model 6B).
2. Colorimeter cuvettes, 12 x 75 mm.
3. One ml pipettes and a 1 ml and 4 ml syringe pipette.
4. Constant temperature water bath, 60° ± 1°C.

Reagents:

1. Dilute sulfuric acid (1.63:1): 190 ml of water plus 310 ml of concentrated sulfuric acid.
2. Phenylhydrazine hydrochloride, recrystallized from ethanol and dried over anhydrous calcium chloride.
3. Phenylhydrazine in acid, 65 mg of the hydrochloride in 100 ml of dilute sulfuric acid, prepared fresh each day.

Procedure:

1. Add 4 ml of phenylhydrazine in acid to a steroid sample in 1 ml of methanol.
2. Heat at 60° ± 1°C for 20 minutes.
3. Cool in running tap water for 3 minutes.
4. Compare the optical density for the steroid solution (A) with that of a methanol-sulfuric acid-phenylhydrazine blank at 410 mμ.
5. In order to correct for interfering substances which yield colored solutions in sulfuric acid, a duplicate sample is treated as above with phenylhydrazine omitted. The optical density (B) is compared with that of a methanol-sulfuric acid blank at 410 mμ.
6. The difference in optical densities, (A-B) is proportional to the quantity of 17,21-dihydroxy-20-ketosteroid in the sample.
7. Prepare standard curves using 25, 12.5, 6.25 and 3.125 mcg of cortisone/ml of absolute methanol.
8. Unknowns are read from the standard curve.

Mader-Buck Reaction

Apparatus:

1. Coleman Junior Spectrophotometer (Model 6B).
2. Colorimeter cuvettes, 12 x 75 mm.
3. One ml pipettes and 1 ml syringe pipette.
4. Fifty ml beakers.

Reagents:

1. 95% ethanol, redistilled.
2. 10% aqueous solution of tetramethylammonium hydroxide.
3. Tetramethylammonium hydroxide in 95% ethanol (Prepare by diluting 3 ml of aqueous 10% solution to 100 ml with 95% ethanol. This solution must be prepared fresh.)

4. Blue tetrazolium [3,3'-dianisole-bis-4,4'-(3,5-diphenyl) tetrazolium chloride].
5. Blue tetrazolium (BT) in 95% ethanol. (Weigh out 35 mg of BT and dilute to 25 ml.) Keep solution in the dark. This solution keeps for at least 4 days when stored in the freezing compartment of a refrigerator.

Procedure:

1. Pipette 1 ml of unknown or standard (in 95% ethanol) into colorimeter tube.
2. Add 1 ml of tetramethylammonium hydroxide in ethanol.
3. Add 1 ml of BT solution.
4. Prepare reagent blank by substituting 1 ml of 95% ethanol for steroid solution.
5. Stopper cuvettes with clean corks and let stand for 15 minutes to 1 hour.
6. Read at 510 mμ, reading each tube against the reagent blank. Reading should be continued until a constant value is observed (not more than 2½ hours). If method blanks have been prepared, the unknowns should be read against them. The time element in preparing blanks is important in this reaction. If too much time is allowed to elapse between the addition of BT solution to the unknowns or standard, and the reagent blank, high values will be observed for the earliest prepared tubes. It is best that every fifth or at least every tenth tube be a reagent or method blank.
7. If the alcoholic extracts of the feces suspension are highly colored, it is essential to run sample blanks where 1 ml of 95% ethanol is substituted for the BT solution. These blanks are read against a reagent blank where 1 ml of 95% ethanol has been substituted for the BT solution. The value of the blank is subtracted from the reading in step 6.
8. At least two standards should be run with each set of determinations.
9. Unknowns are read from a standard curve (25, 12.5, 6.25 and 3.125 mcg of cortisone).

Gornall Reaction

Apparatus:

1. Coleman Junior Spectrophotometer (Model 6B).
2. Colorimeteric cuvettes, 12 x 75 mm.
3. 0.5 ml and 5 ml syringe pipettes.
4. 0.5 ml pipettes, calibrated in 0.1 ml.
5. Pyrex test tubes, 15 x 125 mm.
6. Constant temperature water bath.

Reagents:

1. Absolute methanol, reagent grade.
2. 2,4-dinitrophenylhydrazine.

STAT
STAT

3. Methanolic HCl (3 parts methanol to 1 part concentrated HCl). This solution to be made up weekly.
4. 2,4-dinitrophenylhydrazine in methanolic HCl (1 mg/ml). If stored in a refrigerator, this solution may be used for one week.
5. 4 N sodium hydroxide titrated against standard HCl, phenolphthalein being the indicator. Prepare the NaOH from a filtered lot of saturated NaOH.

Procedure:

1. Transfer a suitable aliquot from the alcoholic solution of the fecal extract to a test tube and evaporate to dryness under reduced pressure.
2. Add 0.5 ml of absolute methanol.
3. Add 0.5 ml of 2,4-dinitrophenylhydrazine in methanolic HCl.
4. Prepare at least two standards and two reagent blanks by adding 0.5 ml of methanol or 0.5 ml of standard plus 0.5 ml of 2,4-dinitrophenylhydrazine to clean test tubes.
5. If extracts are highly colored, fecal blanks are prepared, substituting 0.5 ml of the methanolic HCl for the 2,4-dinitrophenylhydrazine solution.
6. Place tubes in a constant temperature water bath, 50° ± 1°C for 30 minutes. Protect tubes from direct light.
7. Allow tubes to cool a few minutes and add 0.5 ml of 4 N NaOH, mixing well.
8. Dilute with 5 ml absolute methanol and let stand for 20-30 minutes.
9. Transfer to colorimeter tubes and read at 475 mμ. Color is stable for at least one hour.
10. Evaluate unknowns from standard curve (25, 12.5, 6.25 and 3.125 mcg cortisone).
11. Always prepare standard curve for each day's work or for each set of determinations, the latter being preferable.

Preliminary Results: In our hands a few fecal specimens yielded the results summarized in Table AI. 2. These data are presented as preliminary and represent the orders of magnitude of corticoid-like substances in the feces. We have yet no proof that these substances are in fact corticoids or are actually excreted from the body. It may be that the substances are products of bacterial metabolism rather than of metabolic processes within the human body.

TABLE AI. 2

ORDERS OF MAGNITUDE OF STEROID-LIKE MATERIALS FOUND IN FECES FROM ONE HUMAN MALE*

	Subject No. 1	5	6	8
Collection Period	5/25 - 6/1	6/8 - 6/11	6/8 - 6/11	6/1 - 6/8
Dietary Regimen	Recovery Period	Recovery Period	Recovery Period	15/52/33 2000 U
Neutral Extract of Untreated Feces mg/24 hr	7.0	15.0	49.0	9.3
Neutral Extract of Feces Adjusted to pH 1 mg/24 hr	1.5	0.5	2.5	0.7
Neutral Extract of Acid Hydrolyzed Feces mg/24 hr	3.0	0.8	5.0	0.9
Total	11.5	16.3	56.5	10.9

*All values expressed as equivalents of cortisone.

STAT
STAT

References:

Bray, B. M.: Observations on the Use of Girard's Reagents in the Preparation of Crude Urine Extracts for Analysis of 17-Ketosteroids. Analyst, 77:426-429 (Aug.) 1952.

Dobriner, K., Lieberman, S., and Rhoads, C. P.: Studies in Steroid Metabolism I. Methods for the Isolation and Quantitative Estimation of Neutral Steroids Present in Human Urine. J. Biol. Chem., 172:241-261 (Jan.) 1948.

Girard, A. and Sandulesco, G.: Sur une Nouvelle Serie de Reactifs de Groupe Carbonyle, Leur Utilisation à l'Extraction des Substances Cetoniques et à la Caracterisation Microchimique des Aldehydes et Cetones. Helv. Chem. Acta, 19:1095-1107 (Oct.) 1936.

Gornall, A. B. and MacDonald, M. P.: Quantitative Determination of Steroid Hormones with 2,4-Dinitrophenylhydrazine. J. Biol. Chem., 201: 279-97 (March) 1953.

Mader, W. J. and Buck, R. M.: Colorimetric Determinations of Cortisone and Related Ketol Steroids. Anal. Chem., 24:666-667 (April) 1952.

Porter, C. C. and Silber, R. H.: A Quantitative Color Reaction for Cortisone and Related 17,21-Dehydroxy-20-Ketosteroids. J. Biol. Chem., 185:201-207 (July) 1950.

Zimmermann, W.: Eine Farbreaktion der Sexualhormone und ihre Anwendung zur quantitativen Colorimetrischen Bestimmung. Z. Physiol. Chem., 233: 257-264 (June) 1935.

Zimmermann, W.: Colorimetrische Bestimmung der Keimdrüsen-hormone. Z. Physiol. Chem., 245:47-57 (Dec.) 1936.

D. DETERMINATION OF DEUTERIUM OXIDE

1. ESTIMATION OF DEUTERIUM OXIDE IN URINE

Reference: Johnson, R. E., and Pandazi, A. A. Unpublished.

Principle: Deuterium oxide has chemical properties identical with those of hydrogen oxide. Prior to analysis on the basis of its physical properties, pure water is prepared from urine. Its deuterium oxide concentration is then estimated by a falling drop procedure. There are three stages to the estimation.

A. Acid distillation of the urine.
B. Alkaline-permanganate distillation of water from stage A.
C. Estimation of D_2O/H_2O ratio in the pure water.

[redacted]

Stage A. Acid Distillation of the Urine

Equipment and Supplies:

1. 50 ml burette with funnel for conc. H_2SO_4.
2. Two glass still set-ups, each consisting of 3 condenser, 75° 3 extension, 300 ml round bottom 3 flask.
3. Ring stands, triangles and Bunsen burners.
4. Six each, 100 ml graduate cylinders, 50 ml graduated cylinders, 300 ml 3 flasks and 3 inch long stem funnels.
5. Hot air drying apparatus. (One not in use consists of a hot air hair dryer and right angle extension.)
6. Six micro-Kjeldahl digestion flasks and rack.
7. Six place Kjeldahl digestion manifold.
8. 3 necks for Kjeldahl digestion flasks.

Reagents:

1. Conc. H_2SO_4.
2. Distilled water.
3. Glass beads.
4. NaOH (pellets).
5. $KMnO_4$ (fine granular).

Procedure:

1. In each Kjeldahl flask install the 3 neck. Add to each, and set aside for further use the following:
   (a) Six glass beads.
   (b) One pellet NaOH.
   (c) One small spatula $KMnO_4$ (approx. 100 mg).
2. In each 300 ml 3 flask place six glass beads and 1.5 ml conc. H_2SO_4.
3. Add approx. 50 ml urine specimen from 100 ml graduate, mix by swirling and install in distillation apparatus.
4. Wash and start drying the 100 ml graduate cylinder.
5. Turn on water for still and place 50 ml graduates at the tip of the stills.
6. Light a small flame under the flasks and watch carefully for frothing over. After boiling without frothing has been established raise flame to medium.
7. Discard the first 5 ml and collect the next 25-30 ml distillate.
8. Turn off flame and pour distillate into Kjeldahl flask through funnel. Remove funnel and rotate flask gently to dissolve $KMnO_4$ and NaOH.
9. Wash and start drying 50 ml graduates and funnels.
10. Remove and wash and start drying 300 ml 3 flasks and extensions.

Stage B. Alkaline-Permanganate Distillation

Equipment and Supplies:

Battery of 3 stills consisting of the following:

[redacted]

STAT

(a) Air condenser.
(b) 105 - 75 degree S connectors.
(c) Water condenser (perpendicular).
(d) 25 ml graduated cylinders for collecting distillate.
(e) Bunsen burners, tripods, clay triangles.
(f) Rigid racks and clamps for distillation apparatus.

Reagents:

None.

Procedure:

1. Place Kjeldahl flasks on digestion-manifold and heat with gentle flame until boiling has proceeded gently for from 1 to 2 minutes.
2. Turn off flame and remove digestion flasks to rack, smell each and if there is any odor reboil.
3. Remove U necks, wash and commence drying.
4. Install Kjeldahl digestion-flasks at the base of the air condenser, test fit of the connector, install 25 ml graduated cylinder below water condenser and turn on gas very gently.
5. When gentle boiling has commenced without frothing or bumping increase flame slightly so boiling is vigorous.
6. Discard the first 5 ml of the distillate and collect the next 10 ml.
7. After distillation of 10 ml turn off flame and transfer the sample to a clean dry screw cap one half ounce vial for determination of the D_2O/H_2O ratio.

Stage C. Determination of D_2O/H_2O Ratio

This stage is conducted with the falling drop method of Schloerb, Friis-Hansen, Edelman, Solomon and Moore, without any modification.

2. ESTIMATION OF DEUTERIUM OXIDE IN PLASMA AND SERUM.

Reference: Schloerb, P. R., Friis-Hansen, B. J., Edelman, I. S., Solomon, A. K., and Moore, F. D. The Measurement of Total Body Water in the Human Subject by Deuterium Oxide Dilution. J. Clin. Investigation, 29:1296-1310 (Oct.) 1950.

This estimation is carried out exactly according to the authors' directions.

3. ESTIMATION OF BODY WATER BY DEUTERIUM OXIDE DILUTION

Reference: Hurst, W. W., Scherm, F. R. and Vogel, W. C. Urine-Blood Ratios of Deuterium Oxide in Man. J. Lab. and Clin. Med., 39:41-43 (Jan.) 1952.

Principle: A known amount of D_2O is administered either intravenously or by mouth. After equilibration in the body has been achieved, the D_2O/H_2O ratio in serum or in urine is determined. This is representative of the D_2O/H_2O ratio in the body as a whole. From this ratio, and the total amount of D_2O in the body, body water is calculated.

Equipment, Supplies, Procedure:

A. For Serum. This is analyzed by the method of Schloerb et al. (1950) without modification.

B. For Urine. The unpublished method of Johnson and Pinsent (1953) is followed.

Calculation:

$$\text{body water (liters)} = \frac{(\text{gm } D_2O \text{ administered}) - (\text{loss in urine and insensible loss})}{D_2O/H_2O \text{ ratio} \times 10}$$

APPENDIX II

EXPERIMENTAL DATA: TABLE OF CONTENTS

A. ORIGINAL DATA

TABLE AII. 1

RED BLOOD CELL COUNT, millions of cells/mm3

Date 1953	Subject No. 1	2	3	4	12	Date 1953	Subject No. 5	6	7	8
1/9	4.75	5.10	4.68	4.69	---	1/23	5.03	4.89	4.60	4.83
1/16	4.68	5.08	4.80	4.65	---	1/29	---	4.86	---	---
1/22	4.66	5.10	---	4.82	---	1/30	5.10	---	4.71	4.85
1/23	---	---	4.88	---	---	2/6	5.30	4.85	4.65	4.85
1/29	---	5.17	---	---	---	2/9	5.26	---	---	4.76
1/30	4.70	---	4.70	4.67	---	2/10	---	4.90	4.60	---
2/5	4.78	5.08	---	4.65	5.28	2/13	5.03	4.61	4.56	4.48
2/12	4.76	4.86	4.70	---	5.05	2/20	4.90	4.70	4.48	4.40
2/19	4.81	5.03	4.85	---	5.12	2/27	5.28	4.68	4.45	4.40
2/24	---	---	4.94	---	5.02	3/6	5.15	4.80	4.48	4.41
2/26	5.25	5.15	---	---	---	3/9	---	---	4.53	---
3/5	4.95	4.90	4.80	---	4.90	3/13	4.94	4.68	4.75	4.54
3/12	4.80	4.86	4.70	---	4.82	3/20	4.90	4.65	4.40	4.48
3/19	4.85	4.98	4.71	---	4.80	3/27	4.98	4.75	4.38	4.45
3/25	4.86	4.90	4.80	---	4.95	4/3	5.12	4.80	4.46	4.68
4/2	4.80	4.96	---	---	4.81	4/10	4.92	4.90	4.52	4.55
4/9	4.78	5.00	4.50	---	5.00	4/17	4.95	4.90	4.55	4.50
4/16	4.78	5.00	4.85	---	5.00	4/24	4.92	4.70	4.52	4.61
4/21	---	---	---	---	4.97	5/1	5.00	4.73	4.65	4.60
4/23	4.90	4.95	4.78	---	---	5/6	4.95	4.70	---	---
4/30	4.82	4.93	5.01	---	5.06	5/7	---	---	4.75	4.50
5/5	---	4.90	4.87	---	---	5/15	4.85	4.70	4.50	4.55
5/7	4.88	---	---	---	4.90	5/22	4.90	4.60	4.50	4.50
5/14	4.75	5.00	4.90	---	5.05	5/29	4.95	4.70	4.50	4.53
5/21	4.75	4.90	4.92	---	5.10	6/4	---	---	4.70	---
5/28	4.75	4.93	4.90	---	4.88	6/5	5.00	4.83	---	4.50
6/10	4.80	4.98	4.82	---	5.05	6/12	5.06	4.88	---	4.55

TABLE AII. 2

HEMOGLOBIN, gm/100 ml

Date 1953	Subject No. 1	2	3	4	12	Date 1953	Subject No. 5	6	7	8
1/9	15.2	17.0	16.4	16.4	---	1/23	17.0	16.4	15.6	15.6
1/16	14.7	17.0	16.4	16.0	---	1/29	---	16.4	---	---
1/22	15.2	17.0	---	16.4	---	1/30	17.0	---	16.0	16.0
1/23	---	---	17.0	---	---	2/6	17.4	17.0	17.0	16.4
1/29	---	17.0	---	---	---	2/9	17.9	---	---	16.4
1/30	15.6	---	16.4	16.0	---	2/10	---	17.0	16.4	---
2/5	15.2	17.4	---	15.2	17.4	2/13	16.4	15.2	16.0	14.7

STAT

TABLE AII. 2 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
2/6	---	---	16.4	---	---	2/20	16.0	15.2	15.2	14.3
2/12	15.6	17.4	16.0	---	17.4	2/27	16.4	15.2	15.2	14.3
2/19	16.0	17.4	17.0	---	18.4	3/6	17.0	15.6	16.0	15.2
2/24	---	---	17.0	---	18.9	3/9	---	---	17.0	---
2/26	16.4	17.4	---	---	---	3/13	17.0	15.2	15.0	16.0
3/5	14.3	16.0	16.0	---	16.4	3/20	16.0	16.0	15.2	14.3
3/12	13.5	15.6	16.4	---	16.4	3/27	16.4	15.6	15.2	15.2
3/19	15.6	17.0	16.4	---	17.0	4/3	17.0	16.0	15.2	15.6
3/26	15.6	17.0	16.4	---	17.4	4/10	17.0	16.0	16.0	15.6
4/2	15.2	16.4	---	---	17.0	4/17	16.0	15.6	15.6	15.6
4/8	---	---	---	---	17.4	4/24	15.6	15.2	16.0	15.6
4/9	15.2	16.4	15.2	---	---	5/1	17.0	14.7	16.4	16.0
4/16	15.2	17.0	17.4	---	17.9	5/6	16.4	14.7	---	---
4/21	---	---	---	---	17.9	5/8	---	---	16.4	15.6
4/23	15.6	16.4	14.7	---	---	5/15	16.4	15.2	14.7	15.2
4/30	14.7	15.2	16.4	---	16.4	5/22	16.0	15.2	14.7	14.7
5/5	---	15.6	15.6	---	---	5/29	16.0	16.4	14.7	14.7
5/7	14.3	---	---	---	16.0	6/4	---	---	14.7	---
5/14	14.7	16.4	16.4	---	17.9	6/5	16.4	16.0	---	14.7
5/21	14.7	16.4	17.0	---	17.9	6/12	17.0	15.6	---	14.7
5/28	14.3	15.6	15.2	---	16.0					
6/10	14.7	17.0	16.0	---	18.4					

TABLE AII. 3

HEMATOCRIT, Packed Cell Volume, Per Cent

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/9	47	51	47	45	--	1/23	50	47	44	46
1/16	46	51	47	45	--	1/29	--	48	---	--
1/22	47	50	--	45	--	1/30	50	--	44	46
1/23	--	--	47	---	--	2/6	52	52	49	49
1/29	--	51	---	---	--	2/9	52	--	--	49
1/30	47	--	45	45	--	2/10	--	51	48	--
1/5	47	51	--	44	49	2/13	50	43	44	43
1/6	--	--	47	--	--	2/20	46	42	42	40
2/12	47	51	46	--	49	2/27	50	42	43	42
2/19	48	52	49	--	52	3/6	50	44	46	47
2/24	--	--	48	--	52	3/9	--	--	47	--
2/26	50	51	--	--	--	3/13	50	44	45	46
3/5	45	46	44	--	46	3/20	48	47	42	43
3/12	42	46	45	--	46	3/27	49	46	42	43
3/19	48	49	46	--	48	4/3	50	47	43	43
3/26	48	50	46	--	48	4/10	50	46	45	43

TABLE AII. 3 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
4/2	46	47	---	--	48	4/17	49	44	45	45
4/8	--	--	--	--	49	4/24	48	43	46	45
4/9	44	47	45	--	--	5/1	49	43	47	46
4/26	46	50	50	--	49	5/6	48	43	--	--
4/21	--	--	--	--	50	5/8	--	--	50	45
4/23	47	49	43	--	---	5/15	49	44	42	42
4/30	46	44	47	--	47	5/22	47	45	42	43
5/5	--	44	44	--	--	5/29	47	48	45	44
5/7	43	--	--	--	46	5/31	--	--	---	44
5/14	44	48	47	---	50	6/4	--	--	45	--
5/21	44	48	47	--	51	6/5	49	47	--	43
5/28	44	46	44	--	46	6/12	50	46	--	42
6/10	46	48	46	--	50					

TABLE AII. 4

SEDIMENTATION RATE, mm/hr
Uncorrected (Corrected to Hct. of 45%)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/9	4(4)	2(6)	2(2)	10(8)	---	1/23	2(5)	6(6)	3(2)	7(6)
1/16	8(7)	4(8)	3(3)	8(6)	---	1/29	---	6(7)	---	---
1/22	8(8)	5(8)	---	---	---	1/30	2(5)	---	2(1)	9(8)
1/23	---	---	3(3)	11(10)	---	2/6	4(9)	12(17)	8(9)	9(11)
1/29	---	4(8)	---	---	---	2/9	2(6)	---	---	9(11)
1/30	8(8)	---	4(2)	9(7)	---	2/10	---	7(11)	8(9)	---
2/5	8(8)	4(8)	---	9(6)	2(3)	2/13	2(5)	9(6)	6(3)	6(2)
2/6	---	---	3(3)	---	---	2/20	3(2)	11(6)	5(1)	11(3)
2/12	5(5)	4(8)	3(2)	---	2(4)	2/27	2(1)	13(8)	10(6)	14(10)
2/19	11(12)	9(14)	4(6)	---	6(11)	3/6	2(4)	14(11)	13(12)	13(13)
2/24	---	---	3(4)	---	3(6)	3/9	---	---	15(15)	---
2/26	3(3)	7(10)	---	---	---	3/13	2(4)	9(6)	10(8)	10(9)
3/5	6(4)	7(6)	4(2)	---	5(4)	3/20	2(3)	8(8)	7(3)	8(4)
3/12	10(5)	5(4)	2(0)	---	15(14)	3/27	2(4)	9(8)	8(3)	8(4)
3/19	10(11)	9(11)	3(2)	---	8(9)	4/3	2(5)	10(10)	12(8)	11(7)
3/26	10(10)	4(4)	2(2)	---	3(3)	4/10	3(6)	7(6)	5(3)	8(3)
4/2	5(4)	5(5)	---	---	2(3)	4/17	4(6)	9(6)	5(3)	7(5)
4/8	---	---	---	---	3(1)	4/24	2(3)	8(5)	3(2)	6(4)
4/9	9(6)	3(3)	4(2)	---	---	5/1	7(9)	20(17)	5(5)	9(8)
4/16	3(2)	3(6)	3(6)	---	4(6)	5/6	3(4)	12(8)	---	---
4/21	---	---	---	---	2(8)	5/8	---	---	4(6)	9(7)

STAT
STAT

TABLE AII: 4 (contd)

Date	Subject No.					Date	Subject No.				
1953	1	2	3	4	12	1953	5	6	7	8	
4/23	6(6)	5(7)	2(0)	---	---	5/15	3(5)	8(5)	3(0)	8(3)	
4/30	5(4)	3(0)	2(2)	---	5(5)	5/22	5(5)	13(11)	5(0)	8(4)	
5/5	---	4(1)	4(1)	---	---	5/29	5(5)	17(16)	10(8)	12(9)	
5/7	8(4)	---	---	---	5(3)	6/4	---	---	9(7)	---	
5/14	5(2)	2(3)	3(3)	---	3(6)	6/5	3(1)	10(10)	---	11(7)	
5/21	15(12)	3(4)	2(2)	---	2(6)	6/12	5(3)	8(7)	---	10(5)	
5/28	6(3)	6(5)	2(0)	---	3(2)						
6/10	5(4)	5(6)	4(3)	---	4(6)						

TABLE AII. 5

HEMATOLOGICAL INDICES:
Mean Corpuscular Volume (MCV), cu. millimicra
Mean Corpuscular Hemoglobin (MCH), micromcg
Mean Corpuscular Hemoglobin Conc. (MCHC), Per Cent

Date	Subject No.														
	1			2			3			4			12		
1953	MCV	MCH	MCHC	MCV	MCH	MCHC	MCV	MCH	MCHC	MCV	MCH	MCHC	MCV	MCH	MCHC
1/9	99	32	32	100	34	34	100	35	35	96	35	36	---	---	---
1/16	98	31.5	32	96	32	33	98	34	35	97	34	36	---	---	---
1/22	100	32.5	32	98	34	34	---	---	---	---	---	---	---	---	---
1/23	---	---	---	---	---	---	96	34	36	93	34	36	---	---	---
1/29	---	---	---	99	33	33	---	---	---	---	---	---	---	---	---
1/30	100	33	33	---	---	---	95	35	36	96	34	---	---	---	---
2/5	99	32	32	100	34	34	---	---	---	94	32	34	93	33	36
2/6	---	---	---	---	---	---	96	33	35	---	---	---	---	---	---
2/12	101	33	33	103	35	34	98	34	35	---	---	---	97	34	36
2/19	100	33	33	104	34	34	101	35	35	---	---	---	101	36	36
2/24	---	---	---	---	---	---	97	34	36	---	---	---	103	38	36
2/24	95	31	33	99	34	34	---	---	---	---	---	---	---	---	---
3/5	91	29	32	94	33	35	92	33	36	---	---	---	94	34	36
3/12	88	28	32	95	32	34	96	35	36	---	---	---	95	34	36
3/19	99	32	31	98	34	34	98	35	36	---	---	---	100	36	36
3/26	99	32	32	102	34	34	96	34	36	---	---	---	97	35	36
4/2	96	31.5	33	95	33	35	---	---	---	---	---	---	100	36	36
4/8	---	---	---	---	---	---	---	---	---	---	---	---	98	35	36
4/9	92	32	34	94	33	35	100	34	---	---	---	---	---	---	---
4/16	96	32	33	100	34	34	103	36	35	---	---	---	98	36	36
4/21	---	---	---	---	---	---	---	---	---	---	---	---	100	36	36
4/23	96	32	33	99	33	34	90	30	34	---	---	---	---	---	---
4/30	96	30	32	90	31	---	94	32	35	---	---	---	93	32	35

TABLE AII. 5 (contd)

Date	Subject No.											
	1			2			3			12		
1953	MCV	MCH	MCHC	MCV	MCH	MCHC	MCV	MCH	MCHC	MCV	MCH	MCHC
5/5	---	---	---	90	32	36	90	32	36	---	---	---
5/7	88	29	34	---	---	---	---	---	---	94	32	35
5/14	92	31	34	96	33	34	96	34	35	99	36	36
5/21	93	31	34	98	34	34	96	34	36	100	35	35
5/28	93	30	32	94	32	34	90	31	34	94	33	35
6/10	96	30.5	32	96	34	36	96	33	35	99	36	37

Date	Subject No.											
	5			6			7			8		
1953	MCV	MCH	MCHC	MCV	MCH	MCHC	MCV	MCH	MCHC	MCV	MCH	MCHC
1/23	100	34	34	96	34	35	95	34	35	95	32	34
1/30	98	33	34	107	35	32	93	34	32	94	33	31
2/6	98	33	33	107	35	32	104	36	35	101	34	34
2/9	99	34	34	---	---	---	---	---	---	103	34	34
2/10	---	---	---	104	35	33	104	36	34	---	---	---
2/13	99	32	33	93	33	35	96	35	36	96	33	34
2/20	94	32	35	89	32	36	94	33	35	91	32	36
2/27	96	32	33	90	32	36	96	34	35	95	32	34
3/6	97	33	34	92	32	36	102	36	35	108	34	32
3/9	---	---	---	---	---	---	104	38	36	---	---	---
3/13	101	34	34	94	32	34	95	34	36	101	35	34
3/20	98	32	34	101	34	34	96	34	36	96	32	33
3/27	98	33	34	97	33	34	96	34	36	96	34	35
4/3	98	33	34	98	34	34	94	34	36	92	34	36
4/10	101	34	34	94	32	34	100	36	36	96	34	36
4/17	99	32	32	90	32	36	99	34	34	100	34	34
4/24	98	32	32	92	32	36	101	36	35	98	34	34
5/1	98	34	34	91	31	34	101	36	35	100	35	35
5/6	97	33	34	92	32	34	---	---	---	---	---	---
5/7	---	---	---	---	---	---	105	34	33	100	34	34
5/15	101	34	33	94	32	34	94	32	35	92	33	36
5/22	96	32	34	98	33	33	93	32	35	96	32	34
5/29	95	32	34	102	35	34	100	32	32	97	32	34
6/4	---	---	---	---	---	---	96	32	32	---	---	---
6/5	98	33	34	98	33	34	---	---	---	96	32	34
6/12	98	34	34	94	32	34	---	---	---	92	32	35

STAT
STAT

TABLE AII. 6

TOTAL WHITE BLOOD CELL COUNT, thousands of cells/mm^3

DATE	Subject No.					DATE	Subject No.				
1953	1	2	3	4	12	1953	5	6	7	8
1/9	9.25	8.65	7.25	8.00	---	1/23	6.85	7.00	8.55	7.85
1/16	8.00	7.85	8.00	8.15	---	1/29	---	8.00	---	---
1/22	8.90	9.00	---	6.85	---	1/30	8.25	---	7.85	7.15
1/23	---	---	7.50	---	---	2/6	8.20	6.85	7.15	6.85
1/29	---	9.85	---	---	---	2/9	8.00	---	---	7.00
1/30	9.00	---	7.00	9.85	---	2/10	---	6.50	6.85	---
2/5	8.20	8.50	---	10.00	8.70	2/13	8.55	6.25	9.15	7.00
2/6	---	---	7.65	---	---	2/20	7.25	7.00	8.00	7.00
2/12	8.00	8.00	6.05	---	7.45	2/27	7.05	7.00	8.50	8.15
2/19	8.15	9.80	6.85	---	8.00	3/6	7.25	7.00	7.80	7.25
2/24	---	---	6.00	---	7.00	3/9	---	---	7.40	---
2/26	7.50	11.70	---	---	---	3/13	6.35	6.15	8.15	7.40
3/5	7.50	9.00	6.50	---	7.85	3/20	9.00	6.80	8.00	7.60
3/9	8.25	9.05	6.45	---	8.85	3/27	7.70	9.05	9.00	7.35
3/19	8.30	7.25	6.30	---	7.00	4/3	6.80	6.85	8.50	7.00
3/26	9.00	8.40	6.50	---	7.15	4/10	8.10	6.55	7.50	7.85
4/2	8.50	8.85	---	---	7.50	4/17	10.00	8.15	7.25	8.25
4/8	---	---	---	---	11.00	4/24	10.00	9.00	8.65	8.20
4/9	8.30	7.00	8.00	---	---	5/1	7.00	7.00	7.45	6.85
4/16	8.55	8.00	7.00	---	6.85	5/6	7.40	7.00	---	---
4/21	---	---	---	---	7.65	5/8	---	---	8.40	6.20
4/23	8.25	8.00	5.50	---	---	5/15	8.20	8.00	7.00	6.00
4/30	9.50	7.50	6.25	---	7.00	5/22	6.50	7.15	8.50	8.00
5/5	---	8.60	7.85	---	---	5/29	9.15	7.00	7.25	7.25
5/7	9.25	---	---	---	7.65	6/4	---	---	7.85	---
5/14	8.60	8.00	6.00	---	7.50	6/5	7.50	7.65	---	7.00
5/22	8.50	6.75	6.00	---	9.00	6/12	7.25	8.45	---	7.00
5/28	8.35	8.25	5.85	---	7.25					
6/10	7.85	8.70	8.00	---	9.00					

TABLE AII. 7

DIRECT EOSINOPHIL COUNT, cells/mm^3

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/9	155	67	144	122	---	1/23	233	111	188	55
1/16	133	122	111	144	---	1/29	---	66	---	---
1/22	---	---	---	---	---	1/30	200	---	155	44

TABLE AII. 7 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/23	122	144	55	144	---	2/6	111	33	222	55
1/29	---	122	---	---	---	2/9	166	---	---	66
1/30	122	---	166	111	---	2/10	---	88	310	---
2/5	122	100	---	100	222	2/13	144	89	244	44
2/6	---	---	166	---	---	2/20	178	100	244	67
2/12	100	77	122	---	333	2/27	166	67	222	44
2/19	100	67	178	---	278	3/6	166	155	255	22
2/24	---	---	178	---	344	3/9	---	---	311	---
2/26	33	189	---	---	---	3/13	144	100	166	67
3/5	100	166	189	---	222	3/20	233	56	144	33
3/12	100	178	122	---	189	3/27	166	166	211	56
3/19	78	89	122	---	144	4/3	211	78	355	78
3/26	89	222	178	---	322	4/10	200	56	200	67
4/2	122	155	---	---	222	4/17	278	67	255	67
4/8	---	---	---	---	266	4/24	244	89	244	56
4/9	111	155	133	---	---	5/1	100	89	189	44
4/16	78	144	189	---	233	5/6	244	100	---	---
4/21	---	---	---	---	189	5/8	---	---	266	44
4/23	67	144	144	---	---	5/15	311	132	311	67
4/30	111	144	178	---	289	5/22	311	133	287	44
5/5	---	133	155	---	---	5/29	255	100	233	56
5/7	144	---	---	---	211	6/4	---	---	233	---
5/14	122	133	122	---	300	6/5	255	155	---	44
5/21	144	133	222	---	355	6/12	276	211	---	44
5/28	233	122	189	---	278					
6/10	178	111	322	---	222					

TABLE AII. 8

DIFFERENTIAL, Per Cent

Neutrophils (N), Lymphocytes (L), Monocytes (M), Eosinophils (E), and Basophils (B)

Date	Subject No.																			
	1					2					3					4				12	
1953	N	L	M	E	B	N	L	M	E	B	N	L	M	E	B	N	L	M	E	B	N	L	M	E	B
1/9	59	35	1	4	1	50	45	2	1	2	54	43	1	2	0	48	47	0	5	0	--	--	--	--	--
1/16	62	34	2	2	0	55	43	0	2	0	60	35	1	4	0	45	50	0	5	0	--	--	--	--	--
1/22	62	32	3	2	1	46	50	1	3	0	--	--	--	--	--	51	44	2	3	0	--	--	--	--	--

STAT

TABLE XII. 8 (contd)

Date	Subject No. 1					2					3					4					12				
1953	N	L	M	E	B	N	L	M	E	B	N	L	M	E	B	N	L	M	E	B	N	L	M	E	B
1/23	--	--	--	--	--	--	--	--	--	--	53	46	0	1	0	--	--	--	--	--	--	--	--	--	--
1/29	--	--	--	--	--	44	52	0	4	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1/30	59	35	2	4	0	--	--	--	--	--	51	45	1	3	0	45	49	1	5	0	--	--	--	--	--
2/5	65	33	1	1	0	45	55	0	0	0	--	--	--	--	--	42	52	2	3	1	50	44	1	5	0
2/6											49	47	2	2	0										
2/12	62	45	1	2	0	55	43	1	1	0	48	48	2	1	1						47	45	3	5	0
2/19	58	39	0	2	1	54	44	0	2	0	48	49	2	1	0	--	--	--	--	--	66	40	0	0	0
2/24	--	--	--	--	--	--	--	--	--	--	45	47	2	5	1	--	--	--	--	--	50	42	2	5	1
2/26	52	48	1	0	0	49	45	1	3	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3/5	50	48	1	1	0	48	46	3	2	1	50	44	0	4	2	--	--	--	--	--	50	44	1	6	0
3/12	53	43	0	4	0x	50	46	1	2	1	48	49	0	1	2	--	--	--	--	--	51	40	1	7	1
3/19	59	37	0	2	1	44	50	1	4	1	50	47	0	3	0	--	--	--	--	--	54	39	1	6	0
3/26	58	36	2	3	1	45	49	1	5	0	45	50	1	3	1	--	--	--	--	--	45	45	1	7	2
4/2	55	40	0	5	0	45	48	0	6	1	--	--	--	--	--	--	--	--	--	--	50	40	3	6	1
4/8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	51	44	0	4	1
4/9	60	38	1	1	0	45	52	0	3	0	53	44	0	2	1	--	--	--	--	--	--	--	--	--	--
4/16	60	35	3	1	0	44	50	2	3	1	50	42	2	6	0	--	--	--	--	--	49	42	1	7	1
4/21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	50	44	1	4	1
4/23	63	35	1	1	0	45	51	0	2	2	52	44	0	3	1	--	--	--	--	--	--	--	--	--	--
4/30	59	63	1	4	0	45	53	0	2	0	46	47	0	5	1	--	--	--	--	--	43	52	1	4	0
5/5	--	--	--	--	--	43	54	0	3	0	51	46	1	2	0	--	--	--	--	--	--	--	--	--	--
5/7	61	35	0	3	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	45	50	1	3	0
5/14	59	37	2	2	0	46	53	0	1	0	48	48	4	0	0	--	--	--	--	--	46	49	0	4	1
5/21	61	36	0	3	0	40	55	2	3	0	46	49	1	4	0	--	--	--	--	--	46	46	0	7	1
5/28	62	35	0	2	1	45	54	0	1	0	46	50	0	3	0	--	--	--	--	--	51	44	0	4	1
6/10	57	41	0	1	1	47	51	1	1	0	53	42	0	5	0	--	--	--	--	--	51	45	0	4	0

x = trace hypochromia

Date	Subject No. 5					6					7					8					Remarks
1953	N	L	M	E	B	N	L	M	E	B	N	L	M	E	B	N	L	M	E	B	
1/23	47	38	2	8	5	53	44	1	2	0	48	46	0	5	1	40	56	2	2	0	
1/29	--	--	--	--	--	59	39	0	2	0	--	--	--	--	--	--	--	--	--	--	
1/30	42	51	0	7	0	--	--	--	--	--	41	50	0	3	0	57	38	2	2	1	
2/6	52	40	3	4	1	59	37	3	1	0	47	48	0	5	0	42	44	1	2	0	
2/9	54	41	1	4	0	--	--	--	--	--	--	--	--	--	--	57	40	1	1	1	
2/10	--	--	--	--	--	54	43	0	1	0	39	49	1	11	0	--	--	--	--	--	
2/13	45	49	0	5	1	58	40	1	1	0	44	50	1	5	0	53	43	3	1	0	
2/20	41	51	2	6	0	54	45	0	1	0	37	50	1	12	0	55	38	4	3	0	
2/27	40	55	1	3	1	54	43	4	0	0	44	45	1	9	1	60	36	4	0	0	
3/6	41	49	1	7	2	55	41	0	3	1	35	53	1	9	2	61	35	2	1	1	
3/9	--	--	--	--	--	--	--	--	--	--	12	83	0	5	0	--	--	--	--	--	

TABLE XII. 8 (contd)

Date	Subject No. 5					6					7					8					Remarks
1953	N	L	M	E	B	N	L	M	E	B	N	L	M	E	B	N	L	M	E	B	
3/3	46	49	1	3	1	57	39	1	3	0	34	60	1	5	0x	62	38	1	1	0	x=Toxic cells 1+
3/10	42	52	0	4	2	57	43	0	1	0	38	59	0	4	0x	62	35	1	1	1	x=Toxic cells 1+
3/27	41	54	0	3	2	54	43	0	2	1	37	58	0	6	1	61	38	0	0	1	
4/3	46	49	0	5	0	56	41	1	1	1	33	58	1	7	1	53	40	1	4	2	
4/10	58	42	0	3	0	48	50	0	1	1	39	60	0	1	0	59	41	0	0	0	
4/17	46	47	0	6	1	55	43	0	1	1	44	51	1	3	1	59	40	0	1	0	
4/24	51	42	0	6	1	53	44	1	2	0	46	52	0	1	1	56	44	0	0	0	
5/1	54	44	0	1	1	54	40	1	4	1	49	56	0	3	1	54	46	0	0	0	
5/8	50	45	0	3	1	46	48	3	2	1	--	--	--	--	--	--	--	--	--	--	
5/8	--	--	--	--	--	--	--	--	--	--	42	54	0	4	0	49	51	0	0	0	
5/15	46	45	1	6	2	53	43	3	1	0	37	58	0	5	0	54	44	0	1	1	
5/22	46	50	0	4	0	58	40	0	2	0	36	59	0	5	0	54	44	1	1	0	
5/29	48	45	0	5	2	52	44	2	1	1	41	54	0	5	0	57	41	0	2	0	
6/4	--	--	--	--	--	--	--	--	--	--	45	50	0	4	1	--	--	--	--	--	
6/5	48	50	0	2	0	53	43	0	4	0	--	--	--	--	--	55	45	0	0	0	
6/12	61	44	0	4	1	55	42	0	2	1	--	--	--	--	--	55	45	0	0	0	

TABLE XII. 9

DIRECT PLATELET COUNT, thousands of cells/mm^3

Date	Subject No. 1	2	3	4	12	Date	Subject No. 5	6	7	8
1953						1953				
1/9	200	225	255	242	---	1/23	320	275	352	350
1/16	260	230	240	250	---	1/29	---	225	---	---
1/22	230	240	---	360	---	1/30	250	---	290	310
1/23	---	---	300	---	---	2/6	310	218	250	320
1/29	---	220	---	---	---	2/9	325	---	---	300
1/30	275	---	250	325	---	2/10	---	275	254	---
2/5	300	230	---	275	300	2/13	300	300	228	300
2/6	---	---	230	---	---	2/20	325	240	235	228
2/12	225	210	258	---	224	2/26	250	220	300	220
2/19	240	300	220	---	238	3/6	270	308	270	235
2/24	---	---	210	---	204	3/9	---	---	285	---
2/26	210	325	---	---	---	3/13	310	280	268	278
3/5	240	270	225	---	220	3/20	320	285	200	265
3/12	220	242	215	---	210	3/27	300	260	252	280
3/19	209	210	210	---	228	4/3	379	210	220	250
3/26	225	300	240	---	210	4/10	290	225	250	275
4/2	215	200	---	---	205					

STAT
STAT

TABLE AII. 9 (contd)

Date	Subject No.					Date	Subject No.				
1953	1	2	3	4	12	1953	5	6	7	8	
4/9	250	275	225	---	210	4/17	300	230	240	300	
4/16	220	270	235	---	200	4/24	306	230	268	---	
4/21	---	---	---	---	210	5/1	300	225	275	260	
4/23	210	270	200	---	---	5/6	290	230	---	---	
4/30	225	230	245	---	280	5/8	---	---	250	210	
5/5	---	250	210	---	---	5/15	270	200	225	210	
5/7	225	---	---	---	230	5/22	305	260	240	215	
5/14	240	240	235	---	210	5/29	320	250	242	250	
5/21	240	230	210	---	270	6/4	---	---	245	---	
5/28	210	270	215	---	220	6/5	300	215	---	220	
6/10	215	280	205	---	275	6/12	360	220	---	230	

TABLE AII. 10

SERUM CALCIUM, mg/100 ml

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/19	10.8	10.6	11.3	10.4	----	----	----	----	----
2/2	9.3	10.3	9.7	10.4	----	----	10.7	10.4	10.3
2/16	11.0	----	10.2	----	10.0	9.7	9.8	9.6	10.4
2/23	10.4	12.4	10.8	----	11.3	12.3	12.1	11.1	11.5
3/2	9.6	10.4	10.0	----	10.0	11.2	10.0	9.6	10.0
3/16	10.4	10.2	10.0	----	10.3	10.1	10.5	10.2	10.2
3/23	9.6	10.2	10.0	----	9.7	10.2	9.1	10.1	10.1
3/30	9.9	9.8	10.0	----	9.8	9.8	9.8	9.5	10.1
4/13	10.4	10.6	10.8	----	10.6	10.7	11.2	10.5	10.6
4/27	10.6	10.2	8.6	----	8.8	9.4	9.4	9.0	10.0
5/11	10.8	9.6	10.8	----	10.3	11.1	10.6	10.3	11.5
5/25	----	----	----	----	----	11.2	11.3	10.2	11.9
5/26	10.8	11.2	10.0	----	10.9	----	----	----	----
6/8	----	----	----	----	----	10.2	11.0	10.4	10.6
6/10	10.8	10.8	10.6	----	10.0	----	----	----	----

TABLE AII. 11

SERUM CHLORIDES, mEq/l

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/19	98.2	102.3	100.5	94.9	----	----	----	----	----
2/2	100.0	100.0	102.4	100.0	----	99.5	95.3	98.2	98.1
2/16	100.9	92.6	101.3	----	101.8	101.4	109.3	102.3	101.4
3/2	113.0	95.5	95.5	----	109.0	107.0	108.6	108.0	107.0
3/9	104.0	110.0	100.0	----	106.0	99.0	101.0	109.0	105.0
3/16	103.0	100.0	105.0	----	106.0	108.0	115.0	107.0	98.0
3/23	95.0	100.0	102.0	----	102.0	104.0	102.0	103.0	100.0
3/30	104.0	94.0	100.0	----	108.0	106.0	102.0	105.0	106.0
4/6	----	98.0	102.0	----	106.0	102.0	105.0	103.0	----
4/13	101.0	103.0	105.0	----	102.0	104.0	103.0	102.0	105.0
4/27	104.0	105.0	102.0	----	104.0	103.0	102.0	104.0	103.0
5/11	103.0	100.0	105.0	----	103.0	105.0	102.0	99.0	97.0
5/25	100.0	100.0	104.0	----	95.0	104.0	99.0	101.0	101.0
5/31	----	----	----	----	----	----	----	----	108.0
6/1	109.0	98.0	102.0	--	103.0	107.0	109.0	105.0	100.0
6/8	----	----	----	----	----	105.0	100.0	102.0	100.0

TABLE AII. 12

SERUM INORGANIC PHOSPHATE, mg/100 ml

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
2/2	3.80	3.65	3.65	3.40	----	4.50	3.50	4.25	4.10
2/9	4.55	4.55	4.25	4.40	4.50	4.30	4.40	4.55	4.30
2/16	3.95	3.80	3.80	----	4.50	4.65	3.95	4.35	5.00
3/2	3.65	4.55	4.30	----	4.60	4.40	4.40	3.95	4.74
3/16	5.30	4.30	4.40	----	4.40	3.80	3.95	4.65	4.65
3/30	4.55	3.50	4.95	----	4.65	4.55	4.10	4.30	4.10
4/13	4.65	4.30	3.95	----	4.55	3.65	3.65	4.74	4.10
4/27	4.35	3.74	4.80	----	4.50	4.70	4.80	4.80	4.65
5/11	4.10	4.10	4.55	----	----	4.40	4.20	4.40	4.10
5/25	3.80	4.75	4.48	----	3.65	4.55	4.40	4.80	4.65
6/8	----	----	----	----	----	3.42	3.33	3.64	3.33
6/10	4.65	4.30	4.75	----	4.55	----	----	----	----

STAT

TABLE AII. 13

SERUM POTASSIUM, mEq/l

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/12	4.7	5.3	5.2	4.7	---	---	---	---	---
1/19	5.3	5.3	4.8	4.8	---	---	---	---	---
1/26	4.4	4.6	4.1	4.1	---	4.1	4.1	4.1	4.1
2/2	4.4	5.3	4.6	4.6	---	4.4	4.6	4.6	4.4
2/9	4.6	5.0	4.6	4.6	4.6	4.6	4.6	4.6	6.5
2/16	4.4	4.6	4.6	---	4.6	4.6	4.5	5.0	5.3
2/23	5.0	5.0	4.6	---	4.6	4.4	4.6	4.6	4.6
3/2	5.1	4.7	5.3	---	5.2	4.3	4.5	4.5	4.5
3/9	4.6	4.6	4.4	---	4.4	4.4	4.4	4.4	4.6
3/16	4.1	4.6	4.6	---	4.4	4.4	4.4	4.4	4.4
3/23	4.6	4.4	4.4	---	4.4	4.4	4.6	4.4	4.4
3/30	4.4	4.4	4.4	---	4.4	4.4	4.4	4.4	4.4
4/6	4.4	4.4	4.4	---	4.4	4.4	4.4	4.4	4.4
4/13	4.4	4.6	4.0	---	4.0	3.8	3.8	3.8	4.0
4/20	3.8	4.4	3.8	---	3.8	4.0	3.8	3.8	3.8
4/27	4.4	4.6	3.8	---	4.6	4.5	4.1	4.6	4.3
5/4	4.4	4.6	4.8	---	---	4.4	4.3	3.7	3.0
5/11	---	---	3.7	---	4.1	4.5	4.2	4.2	4.7
5/18	4.1	5.0	4.1	---	3.8	4.2	4.2	4.1	4.1
5/25	4.2	4.5	4.0	---	4.3	4.5	4.4	4.2	4.2
6/1	4.7	5.8	5.3	---	---	4.3	5.2	4.5	4.3
6/8	---	---	---	---	---	---	---	---	---
6/10	4.2	4.8	4.1	---	4.2	---	---	---	4.4
6/13	---	---	---	---	---	4.4	4.3	---	

TABLE AII. 14

SERUM SODIUM, mEq/l

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/12	147	145	151	145	---	---	---	---	---
1/19	145	145	145	144	---	---	---	---	---
1/26	152	152	149	143	---	144	149	144	147
1/27	---	---	152	---	---	---	---	---	---
2/2	143	149	147	144	---	147	147	147	147
2/9	144	147	147	144	144	141	141	141	141
2/16	145	147	145	---	147	143	147	149	149
2/23	145	143	145	---	145	149	147	145	147

TABLE AII. 14 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
3/2	145	147	149	---	145	143	145	143	145
3/9	144	144	147	---	144	143	143	143	143
3/16	141	144	143	---	140	143	143	143	141
3/23	141	140	143	---	137	143	137	142	144
3/30	135	137	137	---	141	137	140	137	137
4/6	137	140	140	---	135	137	137	140	140
4/13	135	137	143	---	140	140	137	137	143
4/20	140	141	141	---	143	144	137	135	137
4/27	140	137	141	---	143	140	140	137	140
5/4	147	142	152	---	150	147	147	159	144
5/11	---	---	142	---	---	146	146	143	143
5/18	144	156	151	---	147	152	142	144	150
5/25	142	146	146	---	146	143	144	146	144
6/1	---	150	---	---	145	146	146	144	144
6/8	---	---	---	---	---	146	---	149	144
6/10	145	151	145	---	152	---	---	---	---
6/13	---	---	---	---	---	154	146	---	146

TABLE AII. 15

WHOLE BLOOD GLUCOSE, mg/100 ml

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/12	87	68	87	87	---	---	---	---	---
1/19	83	68	87	87	---	---	---	---	---
1/26	80	66	68	70	---	67	70	76	70
2/2	83	79	93	87	---	89	87	87	95
2/9	75	72	90	68	89	58	45	45	48
2/16	75	72	94	---	72	75	72	68	79
2/23	79	53	95	---	53	79	88	75	79
3/1	88	50	95	---	72	73	79	72	83
3/9	70	68	94	---	75	75	66	52	54
3/16	72	59	79	---	68	57	70	62	54
3/23	72	60	88	---	68	72	75	68	79
3/30	72	52	75	---	68	72	70	64	68
4/6	68	64	75	---	72	60	60	75	75
4/13	78	64	109	---	75	53	68	58	68
4/20	73	75	74	---	56	72	70	72	75
4/27	78	64	90	---	72	72	75	68	72
5/4	85	72	86	---	72	70	72	70	75

STAT

TABLE AII. 15 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
5/11	82	44	94	--	72	75	76	70	73
5/18	75	60	75	--	75	78	75	78	75
5/25	79	72	90	--	72	75	72	79	75
6/1	75	72	90	--	70	70	72	70	67
6/8	--	--	--	--	--	75	75	62	76
6/10	74	62	74	--	58	--	--	--	--
6/13	--	--	--	--	--	79	77	--	79

TABLE AII. 16

SERUM TOTAL PROTEIN, gm/100 ml

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
2/9	----	----	----	7.30	7.80	7.50	7.50	8.30
2/13	7.10	6.90	----	----	6.90	6.30	6.30	6.30
2/16	7.30	7.05	6.65	6.70	6.90	6.45	6.00	6.50
2/23	7.45	7.45	7.25	7.40	7.40	7.25	6.15	7.25
3/2	7.25	7.85	7.00	6.70	7.60	7.45	7.10	7.70
3/9	7.40	7.40	7.00	7.00	7.40	7.40	7.40	7.70
3/16	7.60	7.40	7.20	6.80	6.30	6.30	6.30	7.20
3/23	7.20	7.20	6.60	6.60	6.60	6.20	6.20	6.40
3/30	6.80	6.80	6.80	6.60	6.90	7.00	6.30	7.40
4/6	7.40	7.00	7.40	6.85	7.35	7.50	6.40	7.60
4/13	7.36	6.96	7.70	6.90	7.16	6.20	6.27	7.45
4/20	----	----	----	6.76	7.07	6.87	6.36	7.27
4/27	6.87	7.17	7.07	6.60	6.97	6.87	6.57	7.27
5/4	6.46	7.18	6.56	6.56	7.17	7.07	6.66	6.87
5/11	6.81	7.25	7.00	6.94	6.63	6.94	6.56	7.13
5/18	7.31	7.26	7.06	7.11	6.97	7.11	6.72	7.91
5/25	7.25	6.87	6.93	6.62	6.90	6.81	6.44	7.00
5/31	----	----	----	----	----	----	----	7.38
6/1	6.78	7.76	7.32	7.32	6.83	6.35	6.40	6.73
6/8	----	----	----	----	6.65	6.65	6.60	7.58
6/13	----	----	----	----	6.38	6.55	----	6.98

TABLE AII. 17

SERUM UREA NITROGEN, mg/100 ml

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
2/23	9.2	15.0	14.0	9.0	8.2	8.2	12.0	12.7
3/9	11.2	7.2	10.4	8.3	7.5	5.0	28.5	15.0
3/16	12.7	13.6	17.3	9.6	10.3	14.0	27.5	11.0
3/21	--	--	--	--	--	--	9.75	--
3/23	25.0	15.0	13.5	8.0	8.3	12.5	6.0	9.0
3/30	15.0	11.0	14.7	10.5	11.5	14.7	10.9	8.3
4/3	--	--	--	--	6.0	10.2	--	--
4/6	8.0	10.7	14.2	7.5	4.5	7.5	9.3	17.5
4/13	9.7	13.6	15.7	11.6	5.6	6.4	13.2	8.1
4/20	7.8	15.4	5.8	5.3	13.5	9.8	12.8	7.2
4/27	9.0	11.7	9.7	8.7	10.5	11.7	15.0	10.7
5/4	12.0	10.5	11.3	5.3	10.3	8.3	9.7	8.0
5/11	16.5	15.0	16.5	9.8	9.8	14.2	7.2	5.0
5/18	15.7	9.3	15.0	12.5	19.3	18.0	16.5	17.1
5/25	7.5	12.0	9.8	4.0	10.5	11.3	9.8	8.2
5/31	--	--	--	--	--	--	--	15.0
6/1	15.7	15.0	13.5	10.4	10.4	11.6	8.3	9.6
6/8	--	--	--	--	10.5	9.8	10.5	10.5
6/10	17.3	15.4	18.0	10.2	--	--	--	--
6/13	--	--	--	--	12.0	9.3	--	9.8

TABLE AII. 18

SERUM CREATININE, mg/100 ml

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/22	1.16	1.25	--	--	--	1/23	1.16	1.16	0.90	1.05
1/23	--	--	1.35	1.16	--	1/27	--	1.37	--	--
1/27	--	--	1.37	--	--	1/30	1.35	--	1.25	--
1/29	--	1.50	--	--	--	1/31	--	--	--	1.05
1/30	1.35	--	--	1.35	--	2/6	1.58	1.67	1.37	1.37
2/5	1.16	1.35	1.16	1.25	1.25	2/9	--	--	--	1.58
2/12	1.05	1.16	1.50	--	--	2/10	--	1.67	--	--
2/19	1.16	1.37	1.00	--	1.58	2/11	--	--	1.37	--
2/24	--	--	1.35	--	1.67	2/13	1.00	1.16	1.16	1.16
2/26	1.58	2.15	--	--	--	2/20	1.25	1.16	1.16	1.35
3/5	1.05	1.05	1.00	--	1.00	2/27	1.16	1.16	0.90	1.05
3/12	1.16	1.05	1.05	--	1.00	3/6	1.35	1.35	1.37	1.35

STAT

TABLE AII. 18 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
3/19	1.50	1.67	1.16	——	1.05	3/9	——	——	1.05	——
3/26	1.77	2.15	1.25	——	1.16	3/13	1.00	1.35	1.16	1.37
4/2	1.16	1.16	——	——	1.25	3/20	1.25	1.16	1.05	1.25
4/8	——	——	——	——	1.05	3/27	1.16	1.16	1.16	1.35
4/9	1.25	1.35	1.16	——	——	4/3	1.25	1.35	1.00	1.05
4/16	1.05	1.25	1.00	——	1.00	4/17	1.00	1.00	0.90	1.00
4/21	——	——	——	——	1.16	4/24	1.16	1.00	1.00	1.05
4/23	1.35	1.77	1.05	——	——	5/1	1.16	1.00	1.00	1.16
4/30	1.16	1.00	1.00	——	1.05	5/6	1.35	1.37	——	——
5/5	——	1.00	0.90	——	——	5/8	——	——	——	1.16
5/7	1.00	——	——	——	1.00	5/15	1.05	1.16	1.00	1.00
5/14	1.25	1.25	1.00	——	1.05	5/22	1.16	1.00	0.85	1.05
5/21	1.16	1.16	1.00	——	1.16	5/29	1.16	1.25	1.16	1.05
5/28	0.90	1.05	0.90	——	0.90	5/31	——	——	——	1.37
						6/4	——	——	1.16	——
						6/5	1.16	1.25	——	1.00
						6/12	1.35	1.35	——	1.16

TABLE AII. 19

SERUM TOTAL CHOLESTEROL, mg/100 ml

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/12	176	176	156	298	——	——	——	——	——
1/19	210	213	144	258	——	——	——	——	——
1/26	182	224	145	280	——	172	161	247	190
2/2	179	214	102	256	——	141	138	211	175
2/9	158	133	111	246	148	184	120	252	165
2/16	172	121	109	——	116	165	121	206	219
2/23	219	213	121	——	174	187	174	226	238
3/2	237	213	106	——	153	237	175	267	267
3/9	260	260	168	——	175	213	153	383	367
3/16	275	295	190	——	168	175	153	330	430
3/23	337	399	205	——	198	198	198	275	322
3/30	330	390	168	——	153	221	183	275	314
4/6	252	252	198	——	168	213	205	290	299
4/13	267	290	168	——	145	229	168	307	275
4/20	290	318	129	——	172	330	284	307	314
4/27	290	322	122	——	137	229	190	275	266

TABLE AII. 19 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
5/4	183	252	115	-	175	275	237	283	190
5/11	157	233	129	-	122	233	172	217	241
5/18	190	237	160	-	106	260	205	299	290
5/25	172	198	129	-	92	183	183	283	229
6/1	187	198	172	-	122	198	160	213	245
6/8	-	-	-	-	-	183	153	283	283
6/10	213	275	190	-	168	-	-	-	-
6/13	-	-	-	-	-	198	190	-	245

TABLE AII. 20

SERUM CHOLESTEROL ESTERS, mg/100 ml

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/12	121	137	118	216	-	-	-	-	-
1/19	121	154	100	158	-	-	-	-	-
1/26	134	168	103	198	-	128	119	181	142
2/2	130	164	75	189	-	112	104	162	132
2/9	125	144	96	114	192	160	122	194	170
2/16	125	130	90	-	8[illegible]	120	96	128	133
2/23	165	165	117	-	139	148	139	165	176
3/2	186	205	100	-	141	183	149	205	205
3/9	213	233	153	-	160	183	141	353	330
3/16	245	275	175	-	153	153	129	283	375
3/23	260	345	153	-	160	190	175	221	275
3/30	260	358	153	-	145	213	175	252	299
4/6	229	245	175	-	153	205	175	245	267
4/13	237	267	168	-	137	198	153	260	260
4/20	245	303	100	-	145	252	213	245	252
4/27	260	299	115	-	129	221	183	245	237
5/4	168	213	129	-	153	260	183	213	175
5/11	168	229	141	-	129	190	160	205	175
5/18	164	213	137	-	106	187	183	145	229
5/25	160	190	137	-	85	190	179	267	213
6/1	168	205	153	-	129	198	145	221	237
6/8	-	-	-	-	-	175	160	213	245
6/10	168	205	153	-	149	-	-	-	-
6/13	-	-	-	-	-	175	153	-	198

STAT
STAT

TABLE AII 21

SERUM FREE CHOLESTEROL, mg/100 ml

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/12	55	39	38	82	—	—	—	—	—
1/29	89	59	44	100	—	—	—	—	—
1/26	43	56	42	82	—	44	42	66	48
2/2	49	50	27	77	—	29	34	49	43
2/9	33	0	15	34	44	24	0	68	0
2/16	47	0	19	—	29	45	25	78	76
2/23	54	48	4	—	35	39	35	61	62
3/2	51	8	6	—	12	54	26	62	62
3/9	47	27	25	—	15	30	12	30	37
3/16	30	21	15	—	15	22	24	47	55
3/23	77	54	52	—	38	8	23	54	47
3/30	70	38	15	—	8	8	8	23	15
4/6	23	7	23	—	15	8	30	45	32
4/13	30	23	0	—	8	31	15	47	15
4/20	45	15	29	—	27	78	51	62	62
4/27	30	23	7	—	8	8	7	30	29
5/4	15	39	0	—	22	15	54	70	15
5/11	0	4	0	—	0	43	16	12	66
5/18	26	24	23	—	0	73	22	154	61
5/25	12	8	0	—	0	0	4	16	16
6/1	19	0	19	—	0	0	15	0	8
6/8	—	—	—	—	—	8	0	70	38
6/10	45	70	37	—	19	—	—	—	—
6/13	—	—	—	—	—	23	37	—	47

TABLE AII. 22

WHOLE BLOOD ASCORBIC ACID, mg/100 ml

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/19	1.4	1.6	1.3	1.3	——	——	——	——	——
2/2	1.3	1.6	1.3	1.4	——	1.9	1.4	1.8	1.4
2/16	1.6	1.6	1.4	—	1.5	1.8	1.6	1.4	1.8
3/2	1.1	1.9	1.4	—	1.7	1.3	1.6	1.8	1.6
3/16	1.1	1.2	1.2	—	1.35	1.1	1.15	1.1	1.15
3/30	1.0	1.3	0.9	—	0.9	0.7	0.8	1.1	1.2
4/13	1.4	1.4	1.2	—	1.2	1.2	——	0.7	0.9
4/27	0.9	1.35	0.85	—	1.6	1.6	1.3	1.5	1.5

TABLE AII. 22 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
5/11	1.2	0.95	1.2	—	1.2	1.3	1.25	1.1	1.05
5/25	1.2	1.2	1.1	—	1.65	1.3	1.65	2.0	1.8
6/8	—	—	—	—	—	1.3	1.3	—	1.1
6/10	1.15	1.05	1.35	—	1.3	—	—	—	—

TABLE AII. 23

SERUM AMYLASE, Amylase Units/100 ml

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
2/2	75	121	59	75	—	97	83	33	101
2/16	31	105	40	—	159	70	82	22	113
3/2	83	53	46	—	121	60	75	53	83
3/16	76	82	82	—	114	54	90	76	68
3/30	60	82	76	—	98	90	76	68	82
4/13	96	96	76	—	128	52	46	60	90
4/27	96	106	60	—	183	90	96	60	96
5/11	82	114	79	—	86	82	68	41	52
5/25	38	113	53	—	343	68	57	83	90
6/1	—	—	—	—	106	—	—	—	—
6/8	—	—	—	—	—	82	80	56	114
6/19	96	120	60	—	114	—	—	—	—

TABLE AII. 24

SERUM CHOLINESTERASE, ΔpH/hr

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/12	0.85	0.93	0.86	1.08	——	——	——	——	——
1/19	0.76	0.97	0.88	1.07	——	——	——	——	——
1/26	0.77	1.02	0.89	1.13	——	0.66	0.91	0.69	1.18
1/27	——	——	0.72	——	——	——	——	——	——
2/2	0.80	1.01	0.65	1.08	——	0.63	——	0.70	1.14

STAT

TABLE AII. 24 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
2/9	0.77	0.96	0.77	——	0.85	0.62	——	0.80	1.71
2/10	——	——	——	——	——	——	1.20	——	——
2/16	0.80	0.91	0.73	——	0.63	0.49	0.69	0.48	1.21
2/23	0.68	0.94	0.79	——	0.74	0.56	0.78	0.50	1.24
3/2	0.58	0.83	0.56	——	0.53	0.57	0.86	0.66	1.27
3/9	0.58	0.81	0.80	——	0.69	0.60	0.80	0.75	1.50
3/16	0.73	0.93	0.80	——	0.79	0.46	0.61	0.62	1.52
3/23	0.75	1.06	0.80	——	0.84	0.54	0.63	0.62	1.16
3/30	0.72	0.93	0.84	——	0.82	0.56	0.88	0.72	1.40
4/6	0.68	0.89	0.95	——	0.78	0.65	0.98	0.81	1.36
4/13	0.74	1.01	1.00	——	0.77	0.49	0.82	0.74	1.32
4/20	0.77	1.18	0.82	——	0.92	0.56	0.79	0.81	1.42
4/21	——	——	——	——	0.83	——	——	——	——
4/27	0.76	1.05	0.77	——	0.69	0.65	0.91	0.85	1.36
5/4	0.58	0.84	0.67	——	0.80	0.59	0.94	0.87	1.34
5/11	0.65	1.04	0.81	——	0.67	0.48	0.68	0.70	1.18
5/18	0.68	1.04	0.85	——	0.84	——	——	——	——
5/25	0.69	0.83	0.85	——	0.75	——	——	——	——
5/31	——	——	——	——	——	——	——	——	1.24
6/1	0.68	0.92	0.78	——	0.79	0.62	0.82	0.84	1.23
6/8	——	——	——	——	——	0.58	0.86	0.66	1.31
6/10	0.70	0.89	0.80	——	0.79	——	——	——	——
6/13	——	——	——	——	——	0.65	0.83	——	1.15

TABLE AII. 25

SERUM LIPASE, ml 0.05 N NaOH/100 ml

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/19	20	25	4	8	—	—	—	—	—
2/2	10	15	10	10	—	12	8	5	7
2/16	35	15	35	—	10	50	5	25	15
3/16	15	10	15	—	10	20	25	15	10
3/30	30	30	10	—	12	10	10	20	10
4/13	20	33	20	—	18	32	8	18	26
4/27	24	10	16	—	12	20	38	15	24
5/11	13	18	35	—	10	8	47	14	20
5/25	45	14	35	—	20	12	55	26	15
6/8	—	—	—	—	—	10	18	20	8
6/10	4	16	5	—	18	—	—	—	—

TABLE AII. 26

URINARY CALCIUM, mg/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J6/12	312	368	256	——	——	J12/26	216	297	226	288
J12/19	436	420	468	449	——	J26/F2	218	305	304	298
J19/26	193	297	167	240	——	F2/9	169	175	222	207
J26/F2	141	275	283	233	——	F9/16	215	260	214	262
F2/9	331	326	236	413	224	F16/23	247	454	421	282
F9/16	222	220	216	——	202	F23/M2	163	286	282	234
F16/23	160	184	88	——	167	M2/9	26	80	126	145
F23/25	——	——	73	——	151	M9/16	0	24	86	167
F23/26	76	——	——	——	——	M16/23	256	393	401	358
F23/27	——	200	——	——	——	M23/30	137	318	259	296
F25/M2	——	——	200	——	243	M30/A6	56	135	181	215
F26/M2	191	——	——	——	——	A6/13	85	119	240	277
F27/M2	——	232	——	——	——	A13/20	330	451	434	274
M2/9	368	374	220	——	271	A20/27	156	422	297	194
M9/16	332	252	186	——	102	A27/My 3	62	123	57	84
M16/23	117	84	237	——	132	My3/6	51	101	——	——
M23/30	145	195	272	——	183	My3/11	——	——	40	46
M30/A6	376	486	187	——	298	My6/10	157	184	——	——
A6/13	316	264	234	——	171	My10/18	256	194	198	219
A13/20	102	62	94	——	——	My18/25	121	228	220	149
A20/23	——	——	——	——	137	My25/Jul	108	175	105	94
A20/26	94	76	76	——	——	Jul/8	100	212	102	116
A23/26	——	——	——	——	248	Ju8/13	105	186	——	183
A26/My3	340	451	268	——	227					
My3/11	255	218	135	——	125					
My 11/18	84	46	108	——	44					
My18/25	50	52	46	——	20					
My25/Jul	252	358	280	——	222					

TABLE AII. 27

URINARY CHLORIDE, gm NaCl/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J6/12	18.7	18.8	——	19.7	——	J19/26	18.0	16.9	19.0	17.8
J12/19	16.2	15.6	15.9	16.6	——	J26/F2	20.4	23.4	20.5	17.7
J19/26	15.7	16.5	6.0	5.9	——	F2/9	3.0	2.8	3.5	2.7
J26/F2	10.0	16.3	10.5	2.0	——	F9/16	14.5	8.0	2.6	11.8
F2/9	17.6	16.1	12.8	21.9	18.2	F16/23	21.1	25.0	29.3	23.4

STAT
STAT

TABLE AII. 27 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
F9/16	13.5	17.3	15.2	——	21.0	F23/M2	16.3	18.7	24.4	20.2
F16/23	2.3	1.6	3.5	——	2.3	M2/9	1.8	2.8	5.2	3.5
F23/25	——	——	0.0	——	0.0	M9/16	0.0	0.0	4.7	1.4
F23/26	0.0	——	——	——	——	M16/23	25.2	24.8	21.2	21.8
F23/27	——	0.7	——	——	——	M23/30	20.5	23.0	23.8	24.3
F25/M2	——	——	4.7	——	9.2	M30/A6	2.6	1.6	15.4	16.0
F26/M2	2.3	——	——	——	——	A6/13	1.8	0.5	15.2	14.4
F27/M2	——	4.8	——	——	——	A13/20	25.2	24.2	27.8	18.1
M2/9	17.6	16.1	16.0	——	16.2	A20/27	18.7	23.8	23.8	21.1
M9/16	23.4	19.7	11.8	——	27.4	A27/My3	3.0	2.1	2.4	0.9
M16/23	5.8	6.1	10.8	——	15.0	My3/6	1.2	0.7	——	——
M23/30	1.4	3.3	10.3	——	16.0	My3/10	——	——	0.5	0.0
M30/A6	19.2	18.3	7.7	——	22.6	My6/10	19.6	21.5	——	——
A6/13	22.6	18.7	18.6	——	19.0	My10/18	20.0	17.5	15.4	15.9
A13/20	2.8	2.5	2.0	——	7.0	My18/25	21.9	15.9	19.4	17.0
A20/23	——	——	——	——	4.6	My25/Jul	14.3	14.6	3.2	3.0
A20/26	1.2	0.7	5.2	——	——	Jul/8	15.5	16.0	6.3	5.4
A23/26	——	——	——	——	15.4	Ju8/13	17.2	9.5	——	8.3
A26/My3	20.5	16.7	13.3	——	16.9					
My3/11	26.2	16.4	13.8	——	19.1					
My 11/18	7.0	1.2	1.6	——	1.9					
My 18/25	0.0	0.0	0.0	——	0.0					
My25/31	14.7	14.9	13.0	——	20.9					

TABLE AII. 28

URINARY PHOSPHATE, gm P/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J6/12	1.16	1.31	1.44	1.55	——	J19/26	1.20	1.53	0.94	1.16
J12/19	1.17	1.26	1.22	1.34	——	J26/F2	1.25	1.34	1.22	1.17
J19/26	1.16	1.28	1.19	1.39	——	F2/9	1.40	1.43	1.30	1.05
J26/F2	1.15	1.26	1.31	1.12	——	F9/16	0.56	0.70	0.85	0.78
F2/9	1.48	1.13	1.06	1.27	1.21	F16/23	0.98	0.90	0.80	1.00
F9/16	0.96	1.39	1.16	——	1.39	F23/M2	0.87	1.02	1.15	1.23
F16/23	0.76	0.90	0.70	——	1.00	M2/9	0.54	0.48	1.28	1.36
F23/25	——	——	0.51	——	0.70	M9/16	0.45	0.42	0.98	1.11
F23/26	0.62	——	——	——	——	M16/23	0.67	0.98	1.15	0.89
F23/27	——	0.69	——	——	——	M23/30	0.98	1.10	1.25	1.22

TABLE AII. 28 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
F25/M2	——	——	0.90	——	0.37	M30/A6	0.66	0.88	0.97	1.25
F26/M2	0.77	——	——	——	——	A6/13	0.47	0.91	0.79	0.94
F27/M2	——	0.79	——	——	——	A13/20	0.53	0.99	1.45	1.08
M2/9	0.88	0.72	0.78	——	1.10	A20/27	1.10	1.31	1.42	1.02
M9/16	0.83	0.96	0.77	——	0.97	A27/My3	0.78	0.99	0.73	0.52
M16/23	1.32	1.46	0.78	——	0.8	My3/6	0.67	0.80	——	——
M23/30	1.15	1.53	0.90	——	0.89	My3/10	——	——	0.69	0.42
M30/A6	0.85	1.21	0.74	——	1.13	My6/10	0.91	1.16	——	——
A6/13	0.94	0.98	1.22	——	1.19	My10/18	0.86	1.22	0.94	0.72
A13/20	0.86	0.87	0.62	——	0.66	My18/25	0.78	0.89	0.62	0.80
A20/23	——	——	——	——	0.82	My25/Jul	0.90	1.21	1.02	1.00
A20/26	0.84	0.84	0.62	——	——	Jul/8	0.88	0.89	0.84	0.88
A23/26	——	——	——	——	0.58	Ju8/13	0.87	0.81	——	0.77
A26/My3	0.92	1.37	0.72	——	1.05					
My3/11	1.04	0.90	0.98	——	1.16					
My11/18	0.48	0.40	0.62	——	0.42					
My18/25	0.38	0.26	0.38	——	0.24					
My25/31	1.14	1.13	1.21	——	1.02					

TABLE AII. 29

URINARY POTASSIUM, mEq/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J6/12	62	58	38	72	——	J19/26	67	72	76	61
J12/19	68	62	64	64	——	J26/F2	58	63	73	51
J19/26	77	50	50	57	——	F2/9	54	48	57	41
J26/F2	43	45	48	45	——	F9/16	48	38	65	55
F2/9	62	60	38	87	66	F16/23	80	90	128	102
F9/16	56	85	77	——	88	F23/M2	65	70	81	74
F16/23	38	32	39	——	[illegible]	M2/9	32	36	62	60
F23/25	——	——	24	——	18	M9/16	25	24	70	49
F23/26	23	——	——	——	——	M16/23	61	128	86	69
F23/27	——	20	——	——	——	M23/30	73	96	80	106
F25/M2	——	——	31	——	18	M30/A6	20	34	56	48
F26/M2	31	——	——	——	——	A6/13	22	27	62	32
F27/M2	——	54	——	——	——	A13/20	80	178	121	83
M2/9	88	38	55	——	106	A20/27	78	100	93	67
M9/16	81	70	60	——	60	A27/My3	48	60	40	24

STAT

TABLE AII. 29 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
M18/23	65	63	33	—	43	My3/6	30	31	—	—
M23/30	33	55	30	—	31	My 3/10	—	—	33	20
M30/A6	58	63	32	—	64	My6/10	68	102	—	—
A6/13	68	60	38	—	67	My10/18	96	140	76	61
A13/20	36	50	27	—	33	My18/25	84	83	110	84
A20/23	—	—	—	—	22	My25/Jul	40	89	99	55
A20/26	38	30	15	—	—	Jul/8	44	45	96	52
A23/26	—	—	—	—	50	Jul8/13	90	108	—	68
A26/My3	86	51	72	—	66					
My3/11	93	60	60	—	72					
My11/18	20	24	28	—	24					
My18/25	14	17	20	—	24					
My25/31	54	58	84	—	81					

TABLE AII. 30

URINARY SODIUM, mEq/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J6/12	372	350	308	389	—	J19/26	368	362	392	372
J12/19	348	336	358	358	—	J26/F2	405	414	441	366
J19/26	321	358	143	143	—	F2/9	64	48	37	58
J26/F2	299	360	247	80	—	F9/16	301	108	64	168
F2/9	276	285	256	309	350	F16/23	418	452	53	488
F9/16	294	351	319	—	421	F23/M2	317	328	417	374
F16/23	40	80	84	—	92	M2/9	28	72	80	83
F23/25	—	—	0	—	12	M9/16	43	36	84	65
F23/26	8	—	—	—	—	M16/23	342	352	353	319
F23/27	—	20	—	—	—	M23/30	311	372	430	389
F25/M2	—	—	100	—	477	M30/A6	28	27	278	233
F26/M2	79	—	—	—	—	A6/13	47	48	304	282
F27/M2	—	29	—	—	—	A13/20	441	402	456	314
M2/9	389	308	232	—	429	A20/27	320	394	407	273
M9/16	382	315	222	—	350	A27/My3	64	64	49	36
M16/23	95	96	151	—	256	My3/6	36	37	—	—
M23/30	44	84	139	—	258	My3/10	—	—	20	28
M30/A6	284	290	100	—	369	My6/10	388	424	—	—
A6/13	372	328	282	—	468	My10/18	256	326	269	280
A13/20	48	61	43	—	162	My18/25	346	303	374	334

TABLE AII. 30 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
A20/23	—	—	—	—	154	My25/Jul	288	291	115	71
A20/26	48	36	52	—	—	Jul/8	288	302	140	108
A23/26	—	—	—	—	210	Jul8/13	312	216	—	195
A26/My3	396	336	268	—	318					
My3/11	450	328	256	—	371					
My11/18	58	44	52	—	56					
My18/25	0	0	0	—	0					
My25/31	286	296	272	—	413					

TABLE AII. 31

TOTAL URINARY NITROGEN, g/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J6/12	16.2	14.1	14.5	15.2	—	J19/26	16.0	12.7	14.3	14.4
J12/19	14.7	14.2	15.5	17.4	—	J26/F2	16.4	18.1	15.8	16.6
J19/26	13.9	13.8	13.9	14.4	—	F2/9	6.7	13.2	11.5	6.9
J26/F2	12.0	14.9	13.4	13.1	—	F9/16	13.2	10.2	11.1	13.4
F2/9	14.7	13.0	10.1	13.9	15.2	F16/23	14.2	16.0	16.1	16.5
F9/16	11.6	14.4	10.6	—	16.2	F23/M1	14.6	15.4	17.1	15.7
F16/23	10.7	9.1	9.3	—	11.5	M1/9	6.3	5.6	16.5	17.3
F23/25	—	—	4.7	—	8.7	M9/16	4.9	4.8	12.9	15.9
F23/26	7.7	—	—	—	—	M16/23	16.6	16.6	19.7	16.5
F23/27	—	9.5	—	—	—	M23/30	15.9	11.8	22.8	18.8
F25/M2	—	—	11.8	—	12.6	M30/A6	7.7	9.0	10.3	16.0
F26/M2	10.0	—	—	—	—	A6/13	6.2	6.4	13.3	15.6
F27/M2	—	8.6	—	—	—	A13/20	10.2	13.3	19.3	15.3
M2/9	14.7	13.9	9.3	—	13.6	A20/27	11.0	18.1	17.7	11.3
M9/16	15.2	13.9	10.3	—	13.2	A27/My3	10.3	11.5	8.6	6.3
M16/23	20.6	21.4	10.1	—	14.0	My3/6	9.3	8.9	—	—
M23/30	17.6	23.7	13.5	—	16.6	My3/10	—	—	5.9	4.8
M30/A6	16.5	17.1	8.4	—	15.9	My6/10	13.8	14.1	—	—
A6/13	14.6	12.4	13.9	—	15.8	My11/18	13.1	17.0	12.5	10.0
A13/20	9.1	9.8	6.5	—	7.2	My 18/25	12.9	13.0	13.8	12.2
A20/22	—	—	—	—	9.1	My25/Jul	12.7	15.5	12.5	11.2
A20/26	9.4	10.1	5.6	—	—	Jul/8	12.9	15.2	10.4	10.4
A22/26	—	—	—	—	14.3	Jul8/13	13.3	11.8	—	10.9
A26/My3	14.6	13.5	10.7	—	13.1					

TABLE AII. 31 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
My3/11	14.5	11.4	11.1	——	14.8					
My11/18	6.1	4.3	6.1	——	4.7					
My18/25	4.2	7.4	4.0	——	3.5					
My25/31	13.0	12.3	13.2	——	14.0					

TABLE AII. 32

URINARY AMMONIA NITROGEN, mg/2 hr

Date	Subject No.				Date	Subject No.			
1953	1	2	3	12	1953	5	6	7	8
3/12	72.0	25.0	58	69	3/5	28.5	26.8	124	128
3/19	75.0	113	——	22.8	3/9	——	——	80	——
3/26	76.1	69.6	51.5	49.3	3/13	3.0	6.0	22.0	60
4/3	56.9	27.3	——	41.3	3/20	24.5	67.6	34.7	31.3
4/8	——	——	——	43.3	3/27	6.6	24.0	35.1	39.3
4/9	75.6	23.0	54.2	——	4/3	58.7	55.7	62.4	41.4
4/16	46.9	23.6	43.9	33.1	4/10	36.6	24.7	42.3	49.8
4/21	——	——	——	33.5	4/17	33.8	47.0	41.0	43.9
4/23	40.0	35.6	35.8	——	4/24	44.2	62.0	47.7	36.6
4/30	79.7	49.7	56.8	66.5	5/1	37.2	47.6	32.6	27.7
5/5	——	75.0	64.8	——	5/6	37.0	49.0	——	——
5/7	78.6	——	——	58.2	5/8	——	——	22.3	30.8
5/14	27.1	30.4	42.7	37.1	5/15	30.0	61.8	68.8	58.1
5/21	33.1	28.3	33.9	45.7	5/22	61.0	162.3	21.5	55.3
5/28	118.3	39.5	87.3	77.6	5/29	58.8	54.9	20.4	25.0

TABLE AII. 33

URINARY CREATININE, gm/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/8	3.34	2.77	3.40	2.80	——	1/23	3.14	2.85	2.26	2.16
1/15	3.26	2.80	4.10	3.44	——	1/29	——	2.90	——	——

TABLE AII. 33 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/22	2.78	2.50	—	2.48	—	1/30	2.84	—	2.32	—
1/23	—	—	2.76	—	—	2/6	1.78	1.95	1.86	1.55
1/27	—	—	2.90	—	—	2/9	—	—	—	1.49
1/29	—	2.76	—	—	—	2/10	—	1.50	—	—
1/30	1.90	—	—	2.48	—	2/11	—	—	1.92	—
2/5	2.81	2.42	2.50	2.87	2.10	2/13	2.38	2.55	—	2.62
2/12	2.32	2.30	3.30	—	2.79	2/20	2.90	2.84	3.02	2.87
2/19	2.02	2.16	2.02	—	2.16	2/26	2.82	2.32	2.81	2.36
2/24	—	—	1.96	—	1.71	3/6	1.02	1.59	3.06	2.82
2/26	2.04	1.82	—	—	—	3/9	—	—	4.64	—
3/5	2.70	1.92	2.16	—	2.00	3/20	—	2.53	—	1.46
3/12	2.53	2.21	2.18	—	—	3/21	—	—	3.50	—
3/19	4.32	3.46	2.30	—	2.76	3/27	2.87	3.03	1.88	3.33
3/26	2.59	3.52	2.97	—	2.02	4/3	1.86	1.67	1.58	2.70
4/2	2.33	2.00	—	—	2.56	4/9	—	1.51	—	—
4/8	—	—	—	—	2.64	4/10	1.70	—	1.76	2.12
4/9	2.76	2.36	2.53	—	—	4/17	2.36	2.04	2.46	2.64
4/16	2.45	1.98	1.98	—	2.00	4/24	2.32	2.36	2.74	2.48
4/21	—	—	—	—	1.73	5/6	2.05	1.76	—	—
4/23	2.34	1.80	1.83	—	—	5/8	—	—	1.86	1.98
4/30	2.75	2.39	1.98	—	2.32	5/15	2.91	2.66	2.76	2.80
5/5	—	2.45	—	—	—	5/22	2.64	2.15	1.69	2.43
5/7	2.92	—	—	—	2.64	5/29	2.45	2.45	2.66	2.36
5/14	2.06	1.64	1.78	—	1.80	6/4	—	—	2.34	—
5/21	1.90	1.46	1.98	—	1.87	6/5	2.67	2.02	—	2.50
5/28	2.40	1.73	2.18	—	2.30	6/12	2.85	2.49	—	2.46
6/9	2.82	2.19	—	—	—					
6/10	—	—	2.14	—	2.26					

TABLE AII. 34

URINARY CREATINE, gm/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/8	0.59	0.46	0.70	0.58	—	1/23	0.32	0.33	0.30	0.30
1/15	0.75	0.58	0.78	0.70	—	1/29	—	0.33	—	—
1/22	0.44	0.58	—	0.42	—	1/30	0.52	—	0.36	—
1/23	—	—	0.42	—	—	2/6	0.14	0.25	0.14	0.17
1/27	—	—	0.28	—	—	2/9	—	—	—	0.12

STAT

STAT

TABLE AII. 34 (contd)

Date	Subject No.					Date	Subject No.				
1953	1	2	3	4	12	1953	5	6	7	8	
1/29	—	0.30	—	—	—	2/10	—	0.24	—	—	
1/30	0.14	—	—	0.20	—	2/11	—	—	0.14	—	
2/5	0.68	0.46	0.42	0.53	0.67	2/13	0.28	0.57	—	0.28	
2/12	0.62	0.58	0.77	—	0.54	2/20	0.68	0.45	0.70	0.31	
2/19	0.26	0.30	0.26	—	0.44	2/26	0.31	0.38	0.56	0.39	
2/24	—	—	0.25	—	0.31	3/6	0.27	0.17	0.29	0.31	
2/26	0.27	0.45	—	—	—	3/9	—	—	0.60	—	
3/5	0.40	0.20	0.44	—	0.12	3/20	—	0.20	0.47	0.20	
3/12	0.20	0.45	0.18	—	—	3/21	—	—	0.[illegible]	—	
3/19	0.43	0.46	0.46	—	0.42	3/27	0.46	0.42	0.28	0.59	
3/26	0.16	0.28	0.12	—	0.22	4/3	0.45	0.30	0.17	0.41	
4/2	0.30	0.26	—	—	0.36	4/9	—	0.12	—	—	
4/8	—	—	—	—	0.16	4/10	0.18	—	0.19	0.18	
4/9	0.30	0.10	0.12	—	—	4/17	0.10	0.12	0.19	0.20	
4/16	0.12	0.12	0.12	—	0.12	4/24	0.38	0.39	0.45	0.35	
4/21	—	—	—	—	0.14	5/6	0.15	0.14	—	—	
4/23	0.47	0.32	0.33	—	—	5/8	—	—	0.15	0.12	
4/30	0.22	0.39	0.26	—	0.38	5/15	0.56	0.68	0.70	0.78	
5/5	—	0.20	—	—	—	5/22	0.28	0.30	0.12	0.28	
5/7	0.23	—	—	—	0.38	5/29	0.20	0.20	0.24	0.38	
5/14	0.12	0.09	0.08	—	0.46	6/4	—	—	0.18	—	
5/21	0.30	0.12	0.26	—	0.24	6/5	0.16	0.12	—	0.19	
5/28	0.10	0.14	0.36	—	0.38	6/12	0.21	0.27	—	0.27	

TABLE AII. 35

URINARY UROBILINOGEN, Ehrlich Units/2 hr

Date	Subject No.					Date	Subject No.				
1953	1	2	3	4	12	1953	5	6	7	8	
1/8	—	—	—	0.73	—	1/23	0.60	0.43	0.75	0.58	
1/9	—	—	1.26	—	—	1/30	0.62	—	0.82	—	
1/10	0.77	—	—	—	—	1/31	—	—	—	0.64	
1/15	—	—	—	0.73	—	2/6	0.53	1.00	0.57	1.19	
1/16	0.49	0.61	0.77	—	—	2/9	—	—	—	0.64	
1/23	—	—	0.66	—	—	2/10	—	0.33	—	—	
1/30	0.79	—	—	0.97	—	2/11	—	—	0.51	—	
2/5	0.66	0.68	0.48	1.62	1.65	2/13	0.70	1.27	1.00	1.08	
2/12	1.16	0.92	1.73	—	1.27	2/20	1.05	0.97	1.26	1.77	
2/19	0.58	0.43	1.01	—	0.60	2/27	1.08	0.81	—	0.86	

TABLE AII. 35 (contd)

Date	Subject No.					Date	Subject No.				
1953	1	2	3	4	12	1953	5	6	7	8	
2/24	—	—	0.20	—	0.42	3/4	0.84	0.39	1.55	0.84	
2/26	—	0.35	—	—	—	3/9	—	—	0.57	—	
3/5	1.29	1.14	0.54	—	0.84	3/13	0.87	0.85	1.95	1.28	
3/12	1.00	0.70	0.97	—	0.89	3/20	0.44	0.54	0.66	0.65	
3/19	0.93	1.31	0.78	—	1.36	3/27	0.82	0.95	1.24	1.12	
3/26	1.17	0.95	0.94	—	1.15	4/3	0.35	0.64	1.42	1.53	
4/2	1.14	0.62	—	—	0.87	4/10	0.52	0.62	1.05	1.51	
4/8	—	—	—	—	1.14	4/17	0.46	0.50	0.81	0.80	
4/9	0.87	1.23	1.17	—	—	4/24	0.98	0.83	1.26	1.01	
4/16	1.09	0.68	0.42	—	1.69	5/1	1.00	1.01	1.04	1.12	
4/21	—	—	—	—	1.25	5/6	1.58	0.79	—	—	
4/23	2.28	0.70	0.51	—	—	5/8	—	—	—	1.05	
4/30	0.81	0.34	1.82	—	0.87	5/15	0.78	[illegible]	1.69	1.66	
5/5	—	1.21	2.38	—	—	5/22	1.08	1.[illegible]	1.92	1.67	
5/7	1.89	—	—	—	0.99	5/29	1.11	1.60	1.23	0.48	
5/14	0.67	0.93	1.08	—	0.80	6/4	—	—	1.19	—	
5/21	0.98	0.49	0.50	—	0.78	6/5	0.86	0.80	—	1.07	
5/28	1.42	0.89	0.97	—	1.40	6/12	1.52	1.62	—	1.97	

TABLE AII. 36

URINARY ACETONE, mg/24 hr

Date	Subject No.					Date	Subject No.				
1953	1	2	3	4	12	1953	5	6	7	8	
1/9	13.8	17.5	7.4	0.0	—	1/23	0.0	19.5	0.0	21.0	
1/16	0.0	0.0	8.4	0.0	—	1/30	0.0	0.0	0.0	0.0	
1/23	6.7	0.0	0.0	0.0	—	2/6	386.0	300.0	132.0	200.0	
1/30	0.0	0.0	0.0	0.0	—	F9/15	1.2	—	—	—	
2/6	26.8	19.2	0.0	14.5	—	2/13	—	0.0	0.0	0.0	
2/13	0.0	0.0	0.0	—	12.4	2/15	0.0	—	—	—	
2/20	95.0	312.0	0.0	—	298.0	2/20	11.5	0.0	0.0	0.0	
2/27	55.8	122.0	0.0	—	0.0	2/27	0.0	0.0	0.0	0.0	
3/6	0.0	0.0	0.0	—	0.0	3/6	0.0	0.0	107.0	301.0	
3/13	0.0	0.0	6.1	—	0.0	3/13	0.0	3.7	0	301.0	
M16/23	47.4	100.0	—	—	—	M16/23	0.0	0.0	0.0	0.0	
3/20	—	—	0.0	—	0.0	4/3	51.0	51.0	0.0	0.0	
M23/30	17.9	156.0	—	—	—	4/10	21.4	—	20.1	0.0	
4/3	0.0	0.0	—	—	0.0	4/17	20.9	17.9	0.0	0.0	
4/10	0.0	0.0	0.0	—	20.3	4/24	0.0	28.4	27.5	39.5	

STAT
STAT

TABLE AII. 36 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
4/17	19.5	6.5	4.8	----	14.5	5/1	0.0	11.5	2.4	7.7
4/24	0.0	6.8	0.0	----	10.3	5/8	0.0	17.2	0.0	0.0
5/1	0.0	0.0	5.9	----	13.4	5/15	----	----	0.0	0.0
5/8	0.0	0.0	0.0	----	9.6	5/22	12.7	----	15.3	15.9
5/15	0.0	0.0	0.0	----	0.0	6/5	0.0	0.0	0.0	----
5/22	0.0	0.0	0.0	----	0.0	6/13	0.0	0.0	----	0.0

TABLE AII. 37

ADDIS COUNT: RED BLOOD CELLS, cells/2 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/22	0	0	-	0	0	1/23	-	-	0	0
1/23	-	-	0	-	-	1/29	-	0	-	0
1/28	-	-	0	-	-	1/30	0	-	0	0
1/29	-	0	-	-	-	2/5	0	-	-	0
1/30	0	-	-	0	0	2/6	-	52,800	0	0
2/5	0	0	0	0	0	2/9	-	-	-	0
2/12	0	0	0	-	0	2/10	-	0	0	-
2/19	0	0	0	-	0	2/11	-	-	-	0
2/24	-	-	2,770	-	0	2/12	0	-	0	-
2/26	0	0	-	-	0	2/13	-	0	0	0
3/5	0	0	0	-	0	2/20	0	0	0	0
3/12	0	0	0	-	0	2/27	0	0	0	7,995
3/19	0	0	0	-	0	3/6	2,397	3,620	0	-
3/26	0	0	0	-	0	3/9	-	-	0	0
4/2	0	0	-	-	0	3/13	0	3,595	0	0
4/8	-	-	-	-	0	3/20	0	0	0	0
4/9	0	0	0	-	0	3/27	0	0	0	0
4/16	0	0	0	-	0	4/3	0	0	0	0
4/21	-	-	0	-	0	4/10	0	0	0	0
4/23	0	0	0	-	0	4/17	0	8,125	0	0
4/29	0	0	0	-	0	4/24	0	0	0	0
5/5	-	-	-	-	0	5/1	0	0	0	0
5/7	0	-	-	-	0	5/6	0	0	0	0
5/14	7,500	0	0	-	0	5/8	-	0	2,800	0
5/21	2,400	0	2,000	-	0	5/15	0	0	0	0
5/28	0	0	0	-	0	5/22	0	0	0	0

TABLE AII. 37 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
						5/29	0	0	0	0
						6/4	-	-	0	-
						6/5	0	0	-	0
						6/12	0	0	-	0

TABLE AII. 38

ADDIS COUNT: CASTS, Thousands of casts/2 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/22	0	0	-	0	-	1/23	0	0	0	0
1/23	-	-	0	-	-	1/29	-	0	-	0
1/28	-	-	0	-	-	1/30	0	-	0	0
1/29	-	0	-	-	-	2/5	216.0	-	0	-
1/30	0	-	-	0	-	2/6	-	158.4	0	17.2
2/5	0	0	0	0	0	2/9	-	-	-	4.1
2/12	0	0	0	-	0	2/10	-	529.0	-	-
2/19	0	8.0	0	-	0	2/11	-	-	0	-
2/24	-	-	2.8	-	30.2	2/12	0	-	-	-
2/26	238.0	180.0	-	-	-	2/13	-	0	0	0
3/5	0	0	0	-	0	2/20	0	0	0	0
3/12	0	0	0	-	0	2/27	0	0	0	0
3/19	0	0	0	-	0	3/6	0	0	0	0
3/26	0	0	0	-	0	3/9	-	-	0	-
4/2	0	0	-	-	0	3/13	0	0	0	0
4/8	-	-	-	-	0	3/20	0	0	0	0
4/9	0	0	0	-	0	3/27	0	0	0	0
4/16	0	0	0	-	0	4/3	0	0	0	0
4/21	-	-	0	-	0	4/10	0	0	0	0
4/23	0	0	0	-	-	4/17	0	0	0	0
4/29	0	0	0	-	0	4/24	0	0	0	0
5/5	-	0	0	-	-	5/1	0	3.7	0	-
5/7	0	-	-	-	0	5/6	0	8.0	-	-
5/14	0	5.5	5.1	-	0	5/8	-	-	0	0
5/21	0	64.8	54.0	-	7.7	5/15	0	0	0	0
5/28	0	0	0	-	0	5/22	0	0	0	0
						5/29	0	6.4	0	0
						6/4	-	0	-	0
						6/8	0	0	-	0
						6/12	0	0	-	0

STAT

TABLE AII. 39

ADDIS COUNT: WHITE BLOOD CELLS, cells/2 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/22	3,921,000	47,952	---	720,000	---	1/23	0	170,400	118,800	0
1/23	---	---	0	---	---	1/29	---	28,504	---	---
1/28	---	---	0	---	---	1/30	0	---	96,000	0
1/29	---	13,750	---	---	---	2/5	144,000	---	---	---
1/30	2,940,000	---	---	20,000	---	2/6	---	52,800	12,525	4,250
2/5	3,290,000	11,980	6,440	0	13,050	2/9	---	---	---	0
2/12	3,330,000	0	0	---	8,658	2/10	---	25,210	---	---
2/19	2,805,000	15,984	0	---	20,800	2/11	---	---	0	---
2/24	---	---	49,920	---	136,000	2/12	0	---	---	---
2/26	3,170,000	333,000	---	---	---	2/13	---	0	28,800	0
3/5	2,490,000	15,600	122,800	---	15,200	2/20	0	11,568	0	0
3/12	1145,600	25,550	10,400	---	0	2/27	16,000	19,300	12,500	0
3/19	1,190,000	590,400	8,920	---	0	3/6	248,800	146,800	116,800	39,950
3/26	8,332	321,000	0	---	0	3/9	---	---	115,200	---
4/2	50,600	24,560	---	---	0	3/13	288,000	226,500	34,200	11,587
4/8	---	---	---	---	12,250	3/20	0	0	19,300	0
4/9	1,835,000	94,000	35,800	---	---	3/27	0	0	13,053	0
4/16	40,750	0	0	---	5,725	4/3	144,600	4,250	0	8,130
4/21	---	---	---	---	98,500	4/10	96,000	13,200	16,350	20,500
4/23	29,400	3,600	0	---	---	4/17	0	8,125	0	13,750
4/29	42,300	13,600	0	---	0	4/24	24,[illegible]	12,640	0	22,200
5/5	---	14,100	0	---	---	5/1	[illegible]	7,500	11,200	11,700
5/7	252,000	---	---	---	0	5/6	[illegible]	8,000	---	---
5/14	504,000	98,200	45,600	---	74,000	5/8	---	---	101,000	10,800
5/21	1,530,000	64,800	54,000	---	139,200	5/15	12,560	0	14,250	0
5/28	1,180,000	15,185	10,400	---	0	5/22	65,200	5,850	0	0
						5/29	18,700	57,500	13,600	14,800
						6/4	---	---	0	---
						6/5	23,400	25,200	---	28,900
						6/12	14,400	22,000	---	0

371

TABLE AII. 40

ADDIS COUNT: EPITHELIAL CELLS, cells/2 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/22	364,800	28,671	---	---	---	1/23	0	85,200	237,600	0
1/23	---	---	7,992	216,000	---	1/29	---	71,250	---	---
1/28	---	---	16,400	---	---	1/30	17,200	---	42,560	18,700
1/29	---	27,800	---	---	---	2/5	216,000	---	---	---
1/30	725,600	---	---	61,250	---	2/6	---	105,600	12,525	6,500
2/5	353,000	36,950	12,800	30,360	239,000	2/9	---	---	---	8,180
2/12	230,300	17,200	131,500	---	20,600	2/10	---	---	151,200	---
2/19	216,200	144,000	0	---	6,915	2/11	---	---	22,800	---
2/24	---	---	5,511	---	34,000	2/12	28,000	---	---	---
2/26	317,000	112,500	---	---	---	2/13	---	4,250	129,500	0
3/5	177,600	110,000	13,600	---	30,600	2/20	69,821	23,[illegible]8	234,600	2,887
3/12	436,800	230,400	280,000	---	34,750	2/27	16,000	9,600	22[illegible],300	0
3/19	273,000	32,850	17,010	---	25,000	3/6	67,000	46,950	66,400	144,000
3/26	278,000	61,100	15,700	---	445,500	3/9	---	---	99,200	---
4/2	151,200	36,700	---	---	0	3/13	67,000	129,[illegible]00	145,500	268,500
4/8	---	---	---	---	12,250	3/20	317,000	146,[illegible]00	357,000	26,500
4/9	244,000	42,020	216,000	---	---	3/27	74,[illegible]00	36,[illegible]00	52,000	24,000
4/16	20,400	9,856	13,200	---	5,725	4/3	72,[illegible]00	17,[illegible]00	0	45,600
4/21	---	---	---	---	49,920	4/10	48,[illegible]00	7,[illegible]5	29,100	26,540
4/23	29,400	7,200	11,300	---	---	4/17	48,000	28,[illegible]50	42,000	65,500
4/29	85,200	6,800	23,100	---	21,150	4/24	24,[illegible]00	25,[illegible]00	17,600	22,200
5/5	---	14,100	12,250	---	---	5/1	12,[illegible]00	7,[illegible]00	3,720	5,900
5/7	61,500	---	---	---	18,700	5/6	17,000	4,000	---	---
5/14	201,000	49,400	10,100	---	24,800	5/8	---	---	25,200	21,600
5/21	108,600	97,200	36,000	---	139,600	5/15	25,200	11,650	14,250	26,500
5/28	37,000	7,600	10,100	---	17,[illegible]00	5/22	39,[illegible]00	5,650	0	14,[illegible]00
						5/29	9,325	12,600	13,600	3,720
						6/4	---	---	14,900	---
						6/5	11,700	16,750	---	28,900
						6/12	14,400	14,700	---	0

372

STAT

TABLE AII. h1

URINARY 17-KETOSTEROIDS, mg/24 hr

Date	Subject No.				
1953	1	2	3	h	12
J 5/12	12.1	11.3	18.6	22.0	--
J 13/19	10.6	13.9	16.3	20.7	--
J 20/26	10.9	11.0	16.6	2h.8	--
J 27-F 1	5.8	7.5	12.1	22.1	--
F 2/8	13.0	10.2	15.9	22.2	--
F 9/15	9.9	9.0	16.9	--	26.7
F 16/22	6.h	5.1	11.5	--	1h.2
F 23/26	5.7	--	7.2	--	11.3
F 23/27	--	5.8	12.h	--	16.2
M 2/8	11.1	8.h	1h.5	--	25.h
M 9/15	12.h	9.6	15.9	--	28.5
M 16/22	8.8	6.h	11.6	--	2h.1
M 23/29	6.0	h.7	--	--	21.h
M 30-A 5	10.5	7.2	8.6	--	2h.h
A 6/12	13.2	7.7	19.h	--	29.h
A 13/19	6.2	h.0	8.5	--	13.9
A 20/26*	6.6	5.0	7.1	--	--*
A 27-My 3	8.h	6.h	10.5	--	21.1
My h/10	11.2	8.0	13.7	--	23.2
My 11/17	10.3	8.2	1h.0	--	18.7
My 18/2h	10.3	6.3	10.2	--	1h.6
My 25/31	8.3	6.5	10.9	--	18.1
Ju 9/10	9.0	7.9	13.9	--	18.9

Date	Subject No.			
1953	5	6	7	8
J 20/26	9.2	19.3	15.2	20.5
J 27-F 1	10.3	18.9	16.2	25.6
F 2/8	--	8.7	10.3	13.7
F 9/15	5.1	--	7.9	16.2
F 16/22	7.7	15.0	9.1	21.1
F 23-M 1	9.9	19.9	15.h	27.2
M 2/8	8.6	17.3	9.h	17.3
M 9/15	6.7	9.9	8.0	13.7
M 16/22	8.5	15.3	9.h	1h.2
M 23/29	12.5	20.2	16.5	21.8
M 30-A 5	7.1	12.7	1h.h	27.2
A 6/12	--	--	1h.9	19.9

TABLE AII. h1 (contd)

Date	Subject No.			
1953	5	6	7	8
A 13/19	7.0	11.0	1h.2	2h.6
A 20/26	10.h	19.0	1h.1	2h.6
A 27-My 3	9.3	19.0	1h.5	20.6
My h/6	6.6	10.3	--	--
My 7/10	7.8	11.2	9.8	16.1
My 11/17	11.2	19.8	9.3	16.9
My 18/2h	12.1	21.6	1h.6	25.8
My 25/31	10.8	18.2	11.7	22.5
Ju 1/7	10.8	19.9	11.8	20.3
Ju 13	12.8	20.8	--	19.3

*Subject 12 A 22/2h, 12.0; A 25/26, 13.1

TABLE AII. h2

URINARY 17-KETOSTEROIDS IN 2- AND 3-DAY POOLS OF SUBJECTS 7 AND 8, mg/2h hrs

Date	Subject No.		Date	Subject No.	
1953	7	8	1953	7	8
J 21/22	13.3	17.h	A 2/3	1h.h	23.3
J 23/25	15.6	19.6	A h/6	13.h	26.2
J 26/27	13.8	22.6	A 7/8	16.2	20.1
J 28/29	17.5	22.0	A 9/10	1h.6	19.h
J 30-F 1	13.0	21.3	A 11/13	15.3	20.2
F 2/3	12.1	1h.0	A 1h/15	13.7	23.2
F h/5	8.2	13.6	A 16/17	1h.3	22.6
F 6/8	7.h	12.1	A 18/20	13.5	25.0
F 9/10	6.2	10.h	A 21/22	13.8	23.8
F 11/12	6.h	6.h	A 23/2h	13.6	23.8
F 13/15	8.0	18.h	A 25/27	15.3	25.h
F 16/17	9.2	19.8	A 26/29	1h.6	21.2
F 18/19	10.h	22.9	A 30-My 1	1h.9	21.8
F 20/22	9.9	20.h	My 2/h	11.9	18.9
F 23/2h	12.7	27.2	My 5/6	9.7	17.1
F 25/26	15.3	2h.2	My 7/8	10.3	15.8
F 27-M 1	17.5	27.h	My 9/11	9.8	15.h
M 2/3	12.0	21.9	My 12/13	7.1	12.2
M h/5	10.1	16.7	My 1h/15	9.1	16.7
M 6/8	7.6	1h.6	My 16/18	12.2	19.h
M 9/10	6.h	13.7	My 19/20	1h.7	25.3

STAT

TABLE AII. 42 (contd)

Date 1953	Subject No. 7	8	Date 1953	Subject No. 7	8
M 11/12	8.5	14.7	My 21/22	16.2	27.4
M 13/15	9.6	13.7	My 23/25	11.9	25.5
M 16/17	8.1	11.8	My 26/27	13.04	22.2
M 18/19	10.0	14.7	My 28/29	21.1	25.5
M 20/22	10.7	14.9	My 30/Ju 1	11.6	23.4
M 23/24	15.3	20.6	Ju 2/3	12.3	19.6
M 25/26	17.6	21.8	Ju 4/5	12.5	19.7
M 27/30	14.8	24.2	JU 6/8	10.9	21.8
M 31/A 1	15.9	28.6	Ju 9/10	——	24.6
			Ju 11/12	——	29.0

TABLE AII. 43

FECAL WEIGHT, gm/24 hr

Date 1953	Subject No. 1	2	3	4	12	Date 1953	Subject No. 5	6	7	8
J 6/12	——	191	122	164	——	J 19/26	110	107	116	80
J 12/19	119	176	130	104	——	J 26/F 2	87	120	142	129
J 19/26	116	127	108	79	——	F 2/9	——	——	42	——
J 26/F 2	111	141	137	96	——	F 2/10	——	8	——	——
F 2/9	50	147	140	118	147	F 2/16	64	——	——	87
F 9/26	——	——	——	——	69	F9/16	——	——	——	——
F 9/16	——	200	118	——	——	F 10/16	——	173	153	——
F 9/28	85	——	——	——	——	F 16/23	108	170	202	145
F 16/23	——	21	——	——	——	F 23/M 2	——	110	211	134
F 16/26	——	——	48	——	——	F 23/M 16	45	——	——	——
F 26/M 2	——	——	179	——	52	M 2/9	——	11	24	——
F 28/M 2	143	——	——	——	——	M 9/16	——	80	88	57
M 2/3	129	——	——	——	——	M 2/16	——	——	——	——
F 23/M 9	——	157	——	——	——	M 16/23	134	279	268	167
M 2/9	——	——	167	——	272	M 23/30	——	——	271	156
M 3/9	230	——	——	——	——	M 23/A 13	45	——	——	——
M 9/16	66	180	232	——	185	M 30/A 6	——	——	143	——
M 16/23	——	106	174	——	131	A 6/13	——	——	209	73
M 16/A 6	82	——	——	——	——	A 13/20	131	260	248	135
M 23/30	——	64	125	——	109	A 20/27	——	——	284	124
M 30/A 6	——	213	——	——	138	A 20/My4	45	150	——	——
A 6/13	——	244	219	——	142	A 27/My 11	——	——	21	——
A 13/20	——	25	——	——	6	A 27/My 11	——	——	——	47

TABLE AII. 43 (contd)

Date 1953	Subject No. 1	2	3	4	12	Date 1953	Subject No. 5	6	7	8
A 13/20	—	—	76	—	—	My 4/11	146	92	312	—
A 6/25	38	—	—	—	—	My 11/18	122	128	240	128
A 20/27	—	78	—	—	—	My 18/24	44	86	153	67
A 23/27	—	—	—	—	258	My 25/Ju 1	72	108	176	58
A 25/27	405	—	—	—	—	Ju 1/8	95	101	—	86
A 27/My 4	302	283	257	—	125	Ju 1/5	—	—	98	—
My 4/11	173	180	143	—	108	Ju 8/11	101	137	—	49
My 11/18	—	34	—	—	—					
My 18/25	—	101	—	—	—					
My 11/25	27	—	—	65	53					
My 25/Ju 1	279	218	—	343	227					

TABLE AII. 44

FECAL CALCIUM, mg/24 hr

Date 1953	Subject No. 1	2	3	4	12	Date 1953	Subject No. 5	6	7	8
J 6/12	—	—	—	—	—	J 19/26	377	597	202	186
J 12/19	322	179	250	234	—	J 26/F 2	347	392	189	319
J 19/26	362	405	277	162	—	F 2/9	55	20	60	55
J 26/F 2	530	422	620	180	—	F 9/16	910	1115	452	645
F 2/9	303	705	505	642	—	F 16/23	825	1140	700	89
F 9/16	435	470	400	—	665	F 23/M 2	372	540	495	422
F 16/23	—	28	—	—	—	M 2/9	—	138	55	—
F 23/M 2	—	27	—	—	—	M 9/16	—	440	230	—
F 16/26	—	—	110	—	55	M 2/16	260	—	—	217
F 16/28	55	—	—	—	—	M 16/23	1427	1882	1182	920
F 28/M 2	1195	—	—	—	—	M 23/30	372	552	827	682
F 26/M 2	—	—	667	—	250	M 30/A 6	—	—	302	265
M 4/8	2358	—	—	—	—	M 30/A 13	350	112	—	—
M 2/9	—	2075	763	—	1815	A 6/13	—	—	392	222
M 9/16	580	920	720	—	720	A 13/20	1482	1997	1195	800
M 16/23	—	325	420	—	337	A 20/27	372	967	1447	490
M 23/30	—	265	435	—	385	A 27/My 4	477	477	90	—
M 16/30	185	—	—	—	—	A 27/My 11	—	—	—	72
M 30/A 6	1340	855	—	—	905	My 4/11	1340	624	307	—
A 6/13	667	580	805	—	1032	My 11/18	1070	1205	1027	630
A 13/20	55	65	—	—	13	My 18/25	392	552	670	340
A 13/27	—	—	342	—	—	My 25/Ju 1	335	532	302	240
A 20/24	610	—	—	—	—	Ju 1/5	—	—	180	—
A 24/27	2065	—	—	—	—	Ju 1/8	287	355	—	257

STAT

TABLE AII. 44 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
A 23/27	–	–	–	–	990	Ju 8/11	670	1142	–	304
A 20/27	–	285	–	–	–					
A 27/My 4	690	1525	882	–	567					
My 4/11	985	772	680	–	715					
My 11/18	–	90	–	–	–					
My 11/25	117	–	262	–	130					
My 18/25	–	402	–	–	–					
My 25/Ju 1	1530	1077	1492	–	1767					

TABLE AII. 45

FECAL PHOSPHATE, mgP/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J 6/12	0.24	0.28	0.30	0.30	—	J 19/26	0.37	0.37	0.29	0.24
J 12/19	0.24	0.18	0.17	0.21	—	J 26/F 2	0.37	0.45	0.41	0.37
J 19/26	0.32	0.32	0.42	0.32	—	F 2/9	0.06	0.04	0.09	0.06
J 26/F 2	0.47	0.37	0.38	0.34	—	F 9/16	0.50	0.60	0.40	0.94
F 2/9	0.26	0.35	0.43	0.43	0.60	F 16/23	0.51	0.69	0.55	0.53
F 9/16	0.23	0.32	0.21	—	0.43	F 23/M 2	0.37	0.43	0.50	0.39
F 16/23	—	0.05	—	—	—	M 2/9	—	0.05	0.06	—
F 23/M 2	—	—	—	—	—	M 9/16	—	0.27	0.19	—
F 16/26	—	—	0.09	—	0.07	M 3/16	0.18	—	—	0.14
F 16/28	0.07	—	—	—	—	M 16/23	0.89	1.46	0.97	0.68
F 28/M 2	0.67	—	—	—	—	M 23/30	0.37	0.43	0.71	0.71
F 23/M 2	—	0.05	—	—	—	M 30/A 6	—	—	0.78	0.21
F 26/M 2	—	—	0.45	—	0.25	M 30/A 13	0.12	0.04	—	—
M 2/8	1.35	1.17	0.65	—	0.97	A 6/13	—	—	0.41	0.39
M 9/16	0.34	0.66	0.59	—	0.52	A 13/20	0.82	1.41	0.78	0.43
M 16/23	—	0.17	0.35	—	0.37	A 20/27	0.37	0.92	1.04	0.44
M 23/30	—	0.21	0.37	—	0.33	A 27/My 4	0.17	0.16	0.04	—
M 16/30	0.10	—	—	—	—	A 27/My 11	—	—	—	0.08
M 30/A 6	0.88	0.62	—	—	0.54	My 4/11	0.82	0.16	0.23	—
A 6/13	0.34	0.47	0.65	—	0.65	My 11/18	0.79	1.14	0.72	0.44
A 13/20	—	0.04	—	—	0.01	My 18/25	0.58	0.41	0.56	0.24
A 13/25	0.10	—	—	—	—	My 25/Ju 1	0.32	0.44	0.42	0.28
A 25/27	1.27	—	—	—	—	Ju 1/5	—	—	0.18	—
A 13/27	—	—	0.15	—	—	Ju 1/8	0.35	0.35	—	0.97
A 23/27	—	—	—	—	0.45	Ju 8/11	0.48	0.66	—	0.22
A 20/27	—	0.17	—	—	—					
A 27/My 4	0.54	0.73	0.54	—	0.34					

TABLE AII. 45 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
My 4/11	0.74	0.59	0.32	—	0.41					
My 11/18	—	0.09	—	—	—					
My 11/25	0.09	—	0.20	—	0.17					
My 18/25	—	0.29	—	—	—					
My 25/Ju1	0.32	0.62	0.90	—	0.99					

TABLE AII. 46

FECAL POTASSIUM, mg/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J 6/12	—	—	—	—	—	J 19/26	343	383	489	229
J 12/19	—	200	200	—	—	J 26/F 2	296	414	571	400
J 19/26	514	429	457	428	—	F 2/9	0	0	171	69
J 26/F 2	526	514	486	500	—	F 9/16	0	446	521	475
F 2/9	314	605	514	514	—	F 16/23	272	320	443	340
F 9/16	267	686	257	—	441	F 23/M 2	273	171	1021	371
F 16/23	69	57	48	—	69	M 2/9	135	—	94	171
F 23/25	—	—	48	—	69	M 9/16	135	166	286	171
F 23/27	69	57	—	—	—	M 16/23	410	857	960	628
F 25/M 2	—	—	300	—	200	M 23/30	273	318	1159	457
F 26/M 2	700	—	—	—	—	M 30/A 6	128	160	557	229
F 27/M 2	—	57	—	—	—	A 6/13	128	160	697	236
M 2/9	980	1133	—	—	814	A 13/20	286	769	857	336
M 9/16	286	586	630	—	436	A 20/27	273	873	771	394
M 16/23	164	337	566	—	343	A 27/My 4	67	67	94	107
M 23/30	164	343	357	—	371	My 4/6	498	189	—	—
M 30/A 6	833	500	—	—	371	My 6/10	336	454	—	—
A 6/13	380	429	875	—	543	My 4/10	—	—	774	107
A 13/20	28	24	270	—	0	My 10/18	316	494	593	—
A 20/22	—	—	—	—	0	My 18/25	180	303	616	257
A 20/27	383	200	270	—	—	My 25/Ju 1	269	196	571	229
A 22/27	—	—	—	—	168	Ju 1/8	340	309	250	309
A 27/My 4	93	893	822	—	257	Ju 8/11	200	246	—	117
My 4/11	586	633	579	—	204					
My 11/18	180	89	233	—	237					
My 18/25	180	386	233	—	237					
My 25/Ju1	749	754	1129	—	719					

STAT
STAT

TABLE AII. 47

FECAL SODIUM, mg/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J 6/12	-	-	-	-	-	J 19/26	51	71	57	57
J 12/19	-	10	54	-	-	J 26/F 2	59	57	92	64
J 19/26	69	43	94	14	-	F 2/9	29	43	0	29
J 26/F 2	57	67	100	43	-	F 9/16	13	103	91	43
F 2/9	14	150	92	29	-	F 16/23	14	69	171	51
F 9/16	10	86	100	-	67	F 23/M 2	5	29	75	50
F 16/23	10	7	36	-	29	M 2/9	5	-	16	7
F 23/25	-	-	36	-	29	M 9/16	5	45	21	7
F 23/27	10	7	-	-	-	M 16/23	15	64	64	45
F 25/M 2	-	-	140	-	30	M 23/30	43	50	64	29
F 26/M 2	25	-	-	-	-	M 30/A 6	0	18	29	29
F 27/M 2	-	7	-	-	-	A 6/13	0	18	100	36
M 2/9	35	131	-	-	171	A 13/20	21	86	100	37
M 9/16	0	44	165	-	129	A 20/27	43	50	430	43
M 16/23	15	15	126	-	86	A 27/My 4	0	22	86	11
M 23/30	15	428	169	-	86	My 4/6	37	24	-	-
M 30/A 6	12	43	-	-	50	My 6/10	54	21	-	-
A 6/12	31	71	171	-	129	My 4/10	-	-	40	11
A 13/20	32	0	68	-	5	My 10/18	54	21	660	-
A 20/22	-	-	-	-	5	My 18/25	20	43	29	21
A 22/27	-	-	-	-	13	My 25/Ju 1	32	53	91	36
A 20/27	53	36	68	-	-	Ju 1/8	61	36	38	50
A 27/My 4	92	206	214	-	56	Ju 8/11	33	55	-	17
My 4/11	82	66	101	-	102					
My 11/18	14	32	45	-	29					
My 18/25	14	32	45	-	24					
My 25/Ju 1	286	110	230	-	117					

TABLE AII. 48

FECAL NITROGEN, gmN/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J 6/12	1.0	2.3	2.0	1.0	-	J 19/26	2.6	1.9	1.5	2.0
J 12/19	2.1	2.0	2.1	0.9	-	J 26/F 2	1.8	2.0	2.5	2.1
J 19/26	2.8	2.5	1.9	1.3	-	F 2/9	0.4	0.1	0.8	0.4
J 26/F 2	2.6	2.8	2.4	1.3	-	F 9/16	2.0	2.4	2.6	2.6
F 2/9	1.0	1.4	2.1	1.9	2.8	F 16/23	2.4	2.9	4.1	2.8

TABLE AII. 48 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
F 9/16	2.5	3.0	2.1	-	2.8	F 23/M 2	2.0	2.1	2.3	2.5
F 16/23	-	0.2	-	-	-	M 2/9	-	0.2	0.5	-
F 16/26	-	-	0.5	-	0.4	M 2/16	0.5	-	-	0.9
F 16/28	0.3	-	-	-	-	M 16/23	2.2	4.7	4.9	3.1
F 23/M 2	-	0.2	-	-	-	M 23/30	2.0	2.0	4.2	1.5
F 26/M 2	-	-	2.6	-	0.65	M 30/A 6	-	-	1.3	2.7
M 2/9	4.1	4.4	2.9	-	5.9	A 6/13	-	-	3.2	1.2
M 9/16	1.6	2.9	3.9	-	3.7	A 13/20	2.6	3.9	4.0	2.8
M 16/23	-	1.8	2.8	-	2.7	A 20/27	1.5	4.6	4.7	2.1
M 23/30	1.0	-	-	-	-	A 27/My 4	0.3	0.4	0.3	-
M 30/A 6	-	1.8	2.1	-	2.2	A 27/My 11	-	-	-	0.5
A 6/13	2.4	2.4	2.3	-	3.3	My 4/11	2.9	1.4	3.17	-
A 13/20	1.0	0.4	-	-	0.1	My 11/18	2.3	3.5	3.3	1.9
A 13/27	-	-	0.9	-	-	My 18/25	1.4	1.9	2.9	1.5
A 20/27	1.7	1.1	-	-	-	My 25/Ju 1	1.9	2.7	3.3	1.1
A 23/27	-	-	-	-	3.9	Ju 1/5	-	-	1.9	-
A 27/My 4	4.3	3.6	2.7	-	2.2	Ju 1/8	2.1	1.8	-	1.4
My 4/10	3.5	2.8	2.4	-	2.3	Ju 8/11	2.4	2.6	-	1.0
My 11/18	-	0.5	-	-	-					
My 18/25	-	1.4	-	-	-					
My 11/25	0.4	-	0.8	-	0.8					
My 25/Ju 1	3.6	2.4	3.3	-	4.0					

TABLE AII. 49

TOTAL FECAL FAT, gm/24 hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J 6/12	-	2.0	8.0	4.1	-	J 19/26	4.5	4.7	3.8	2.3
J 12/19	3.6	2.0	2.5	2.4	-	J 26/F 2	2.7	4.7	5.8	3.9
J 19/26	7.5	2.7	5.7	2.3	-	F 2/9	0.4	0.1	0.8	0.4
J 26/F 2	9.1	4.5	4.9	1.9	-	F 9/16	4.6	10.4	5.8	7.1
F 2/9	3.5	4.3	10.0	5.1	4.9	F 16/23	5.1	6.8	14.0	7.3
F 9/16	6.7	5.7	6.4	-	4.1	F 23/M 2	3.4	5.4	11.8	4.5
F 16/23	-	0.2	-	-	-	M 2/9	-	0.3	0.1	-
F 16/26	-	-	1.0	-	0.4	M 2/16	0.4	-	-	3.0
F 16/28	0.4	-	-	-	-	M 16/23	8.3	16.9	19.5	9.0

STAT

TABLE AII. 49 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
F 23/M 2	-	0.4	-	-	-	M 23/30	3.4	5.4	8.7	4.8
F 28/M 9	16.7	-	-	-	-	M 30/A 6	-	-	6.6	2.8
F 26/M 2	-	-	3.1	-	2.9	M 30/A 13	3.3	2.5	-	-
M 2/9	-	10.2	13.4	-	5.7	A 6/13	-	-	11.8	5.1
M 9/16	7.8	10.1	18.9	-	6.5	A 13/20	5.0	18.8	16.8	4.9
M 16/23	-	5.3	16.5	-	4.3	A 20/26	3.4	17.5	15.1	5.3
M 16/30	3.2	-	-	-	-	A 27/My 4	1.2	1.2	1.4	-
M 23/30	-	3.1	9.5	-	4.8	A 27/My 11	-	-	-	0.5
M 30/A 6	7.1	7.8	-	-	6.5	My 4/11	5.4	5.9	2.3	-
A 6/13	7.6	6.3	20.7	-	8.0	My 11/18	4.5	15.3	11.5	5.5
A 13/20	1.3	0.8	-	-	0.2	My 18/25	3.0	6.6	9.9	3.7
A 13/27	-	-	6.0	-	-	My 25/Ju 1	5.2	6.4	4.1	2.4
A 20/27	-	1.9	-	-	-	Ju 1/5	-	-	2.1	-
A 23/27	-	-	-	-	2.8	Ju 1/8	7.2	4.4	-	2.5
A 27/My 4	16.5	11.2	23.4	-	3.1	Ju 8/11	4.9	6.4	-	1.5
My 4/10	12.0	6.1	12.4	-	3.9					
My 11/18	-	0.5	-	-	-					
My 18/25	-	4.5	-	-	-					
My 11/25	0.7	-	3.0	-	0.6					
My 25/Ju 1	13.0	9.4	24.2	-	13.7					

TABLE AII. 50

CEPHALIN FLOCCULATION, 24 hr/48 hr

Date	Subject No.				Date	Subject No.			
1953	1	2	3	12	1953	5	6	7	8
2/24	-	-	neg/neg	2+/4+	2/27	neg/neg	neg/neg	neg/neg	neg/tr
2/26	2+/4+	neg/+	-	-	3/6	neg/neg	neg/neg	neg/neg	neg/2+
3/5	neg/tr	neg/neg	neg/neg	neg/neg	3/9	-	-	neg/neg	-
3/12	neg/neg	neg/neg	neg/neg	neg/neg	3/13	neg/neg	neg/neg	neg/neg	neg/neg
3/12	neg/2+	neg/neg	neg/neg	neg/neg	3/20	neg/neg	neg/neg	neg/neg	neg/neg
3/26	neg/+	neg/neg	neg/neg	neg/neg	3/27	neg/neg	neg/neg	neg/neg	neg/neg
4/2	neg/neg	neg/neg	-	neg/+	4/3	neg/neg	neg/neg	neg/neg	neg/neg
4/9	neg. (72hr)	neg (72hr)	neg (72hr)	1+ (72hr)	4/10	neg (72hr)	neg (72hr)	neg (72hr)	+ (72hr)
4/16	neg/neg	neg/neg	neg/neg	neg/2+	4/17	neg/neg	neg/neg	neg/neg	neg/+
4/22	-	-	-	3+/4+	4/24	neg/neg	neg/neg	neg/neg	neg/neg
4/23	neg/neg	neg/neg	neg/neg	-	5/1	neg/neg	neg/neg	neg/neg	neg/neg
4/	neg/neg	neg/neg	neg/neg	neg/neg	5/	neg/neg	neg/neg	-	-
5/6	-	neg/neg	neg/neg	-	5/8	-	-	neg/neg	neg/+

381

TABLE AII. 50 (contd)

Date	Subject No.				Date	Subject No.			
1953	1	2	3	12	1953	5	6	7	8
5/7	neg/neg	-	-	neg/neg	5/15	neg/neg	neg/neg	neg/neg	neg/neg
5/14	neg/neg	neg/tr	neg/neg	+/+	5/22	neg/neg	neg/neg	neg/neg	neg/neg
5/21	neg/neg	neg/str	neg/neg	+/+	5/29	neg/neg	neg/neg	neg/neg	neg/2+
5/28	neg/2+	neg/2+	neg/2+	neg/str	6/4	-	-	neg/neg	-
6/10	neg/neg	neg/neg	neg/neg	neg/neg	6/5	neg/neg	neg/neg	-	neg/neg
					6/12	neg/neg	neg/neg	-	neg/neg

TABLE AII. 51

URINARY ACETONE, Diluted, Qualitative

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/5	neg	neg	neg	neg	—	neg	neg	neg	neg
1/8	neg	neg	neg	neg	—	neg	neg	neg	neg
1/11	neg	neg	neg	neg	—	neg	neg	neg	neg
1/13	neg	neg	neg	neg	—	neg	neg	neg	neg
1/15	neg	neg	neg	neg	—	neg	neg	neg	neg
1/18	neg	neg	neg	neg	—	neg	neg	neg	neg
1/20	neg	neg	neg	neg	—	neg	neg	neg	neg
1/22	neg	neg	neg	neg	—	neg	neg	neg	neg
1/25	neg	neg	neg	neg	—	neg	neg	neg	neg
1/27	neg	neg	neg	neg	—	neg	neg	neg	neg
1/29	neg	neg	neg	neg	—	neg	neg	neg	neg
2/1	neg	neg	neg	neg	—	neg	neg	neg	neg
2/3	neg	neg	neg	neg	neg	+	+	+	+
2/5	neg	neg	neg	neg	neg	+	+	+	neg
2/8	neg	neg	neg	neg	neg	+	+	+	tr
2/10	neg	neg	neg	—	neg	neg	2+	4+	tr
2/12	neg	neg	neg	—	neg	—	—	—	—
2/15	neg	neg	neg	—	neg	neg	neg	neg	neg
2/17	3+	2+	neg	—	+	neg	neg	neg	neg
2/19	—	—	—	—	—	neg	neg	neg	neg
2/20	+	3+	tr	—	3+	—	—	—	—
2/21	4+	4+	tr	—	4+	—	—	—	—
2/22	2+	4+	+	—	4+	neg	neg	neg	neg
2/23	tr	2+	neg	—	3+	—	—	—	—
2/24	tr	2+	neg	—	2+	—	—	—	—
2/25	tr	2+	neg	—	tr	neg	neg	neg	neg
2/26	+	2+	neg	—	neg	neg	neg	neg	neg

382

STAT

TABLE AII. 51 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
3/1	—	3+	—	—	—	neg	neg	neg	neg
3/3	neg	neg	neg	—	neg	neg	neg	tr	tr
3/5	neg	neg	neg	—	neg	neg	neg	2+	2+
3/8	neg	neg	neg	—	neg	neg	neg	2+	3+
3/9	—	—	—	—	neg	—	—	—	neg
3/10	neg	neg	neg	—	neg	neg	neg	neg	3+
3/12	neg	neg	neg	—	neg	neg	neg	neg	3+
3/15	—	neg	neg	—	neg	neg	neg	neg	neg
3/17	tr	+	neg	—	neg	neg	neg	neg	neg
3/19	2+	2+	neg	—	neg	neg	neg	neg	neg
3/22	1+	4+	neg	—	neg	neg	neg	neg	neg
3/24	neg	3+	neg	—	neg	neg	neg	neg	neg
3/25	neg	3+	neg	—	neg	neg.	neg	neg	neg
3/26	neg	3+	neg	—	neg	neg	neg	neg	neg
3/29	neg	2+	neg	—	neg	neg	neg	neg	neg
3/31	neg	neg	neg	—	neg	neg	neg	neg	neg
4/2	neg	—	—	—	neg	+	+	neg	neg
4/5	neg	neg	—	—	neg	+	+	neg	neg
4/7	neg	neg	neg	—	neg	tr	tr	neg	neg
4/9	neg	neg	neg	—	neg	neg	—	neg	neg
4/12	neg	neg	neg	—	neg	tr	tr	neg	neg
4/14	neg	neg	neg	—	neg	neg	neg	neg	neg
4/16	neg	neg	neg	—	tr	neg	neg	neg	neg
4/19	neg	neg	neg	—	+	neg	neg	neg	neg
4/21	neg	neg	neg	—	2+	neg	neg	neg	neg
4/23	neg	neg	neg	—	neg	neg	neg	neg	neg
4/26	neg	neg	neg	—	neg	neg	neg	neg	neg
4/28	neg	neg	neg	—	neg	neg	neg	neg	neg
4/30	neg	neg	neg	—	neg	neg	neg	neg	neg
5/3	neg	neg	neg	—	neg	neg	neg	neg	neg
5/5	neg	neg	neg	—	neg	neg	neg	neg	neg
5/7	neg	neg	neg	—	neg	neg	neg	neg	neg
5/10	neg	neg	neg	—	neg	neg	neg	neg	neg
5/12	neg	neg	neg	—	neg	neg	neg	neg	neg
5/14	neg	neg	neg	—	neg	neg	neg	neg	neg
5/17	neg	neg	neg	—	neg	neg	neg	neg	neg
5/19	neg	neg	neg	—	neg	neg	neg	neg	neg
5/21	neg	neg	neg	—	neg	neg	—	neg	neg
5/24	neg	neg	neg	—	neg	neg	neg	neg	neg
5/26	neg	neg	neg	—	neg	neg	neg	neg	neg
5/28	neg	neg	neg	—	neg	neg	neg	neg	neg
5/31	neg	neg	neg	—	neg	neg	neg	neg	—
6/2	—	—	—	—	—	neg	neg	neg	neg
6/4	—	—	—	—	—	neg	neg	neg	neg

TABLE AII. 51 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
6/7	—	—	—	—	—	neg	neg	neg	neg
6/9	neg	neg	—	—	—	neg	neg	—	neg
6/10	—	—	neg	—	neg	—	—	—	—
6/11	—	—	—	—	—	neg	neg	—	neg

TABLE AII. 52

URINARY ACETONE, Undiluted, Qualitative

Date	Subject No.				Date	Subject No.			
1953	1	2	3	12	1953	5	6	7	8
2/16	tr	tr	neg	—	3/7	neg	neg	4+	2+
2/17	3+	3+	neg	2+	3/9	—	—	tr	—
2/18	3+	3+	neg	3+	3/12	—	—	—	4+
2/19	3+	4+	neg	4+					
2/20	2+	4+	tr	4+					
2/21	4+	4+	1+	4+					
2/22	3+	4+	1+	4+					
2/23	tr	4+	tr	4+					
2/24	tr	4+	2+	4+					
2/26	+	4+	—	—					
3/1	—	4+	—	--					
3/19	4+	4+	—	—					
3/22	2+	4+	—	—					
3/25	tr	4+	—	—					
3/26	tr	4+	—	—					

TABLE AII. 53

URINARY UROBILINOGEN, Qualitative

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/6	+	str	tr	+	-	-	-	-	-
1/8	tr	str	+	+	-	-	-	-	-
1/11	tr	str	tr	+	-	-	-	-	-

STAT

TABLE AII. 53 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/13	tr	+	+	+	–	–	–	–	–
1/15	tr	tr	tr	tr	–	–	–	–	–
1/18	+	neg	+	+	–	–	–	–	–
1/20	+	+	+	+	–	+	tr	tr	+
1/22	tr	tr	tr	+	–	tr	tr	tr	+
1/25	str	tr	tr	+	–	str	tr	+	+
1/27	tr	neg	neg	tr	–	tr	tr	tr	+
1/29	tr	tr	tr	+	–	tr	tr	+	+
2/1	neg	neg	tr	tr	–	tr	tr	str	tr
2/3	str	tr	str	tr	+	+	str	tr	tr
2/5	tr	+	str	neg	+	+	+	+	2+
2/8	str	tr	tr	tr	neg	tr	+	tr	+
2/10	tr	tr	str	–	+	+	+	+	+
2/12	tr	str	neg	–	tr	–	–	–	–
2/15	str	+	tr	–	tr	tr	tr	tr	tr
2/17	tr	tr	tr	–	+	tr	tr	tr	+
2/19	tr	tr	tr	–	tr	+	tr	tr	+
2/22	+	tr	2+	–	+	tr	tr	tr	+
2/24	tr	tr	tr	–	tr	+	tr	tr	+
2/26	tr	tr	+	–	+	+	tr	str	+
3/1	+	tr	str	–	tr	str	tr	neg	tr
3/3	neg	neg	tr	–	+	tr	tr	+	2+
3/5	+	tr	tr	–	+	tr	tr	+	+
3/8	–	tr	tr	–	tr	tr	tr	+	+
3/10	tr	neg	+	–	+	tr	tr	+	+
3/12	2+	tr	tr	–	tr	+	tr	2+	2+
3/15	–	neg	tr	–	tr	+	+	neg	tr
3/17	+	tr	+	–	+	tr	tr	+	tr
3/19	+	tr	tr	–	+	tr	tr	neg	+
3/22	+	+	tr	–	+	tr	+	neg	tr
3/24	tr	+	+	–	+	tr	+	tr	tr
3/26	+	tr	tr	–	neg	tr	neg	tr	tr
3/29	+	2+	neg	–	+	tr	tr	neg	+
3/31	tr	tr	tr	–	+	tr	tr	tr	+
4/2	tr	–	–	–	+	+	+	str	2+
4/5	tr	tr	–	–	tr	+	tr	+	+
4/7	neg	tr	tr	–	+	tr	–	neg	+
4/9	tr	neg	tr	–	+	tr	–	neg	neg
4/12	tr	neg	+	–	neg	neg	tr	neg	neg
4/14	+	+	+	–	2+	tr	tr	tr	tr
4/16	tr	+	+	–	2+	tr	+	+	tr
4/19	+	+	tr	–	2+	tr	+	+	+
4/21	+	tr	tr	–	tr	tr	tr	+	neg
4/23	+	tr	tr	–	tr	+	+	+	+
4/26	+	tr	tr	–	tr	tr	tr	+	tr
4/28	+	tr	tr	–	neg	tr	+	tr	tr

TABLE AII. 53 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
4/30	tr	tr	tr	——	tr	tr	tr	+	2+
5/3	2+	+	2+	——	2+	tr	+	tr	tr
5/5	+	neg	neg	——	tr	tr	2+	tr	tr
5/7	tr	neg	tr	——	neg	tr	tr	+	+
5/10	neg	+	neg	——	neg	neg	neg	2+	tr
5/12	neg	tr	neg	——	tr	tr	tr	tr	tr
5/14	+	+	+	——	+	tr	tr	tr	+
5/17	+	+	tr	——	2+	tr	tr	tr	+
5/19	+	tr	tr	——	+	tr	2+	neg	2+
5/21	tr	neg	tr	——	+	tr	——	neg	tr
5/24	tr	tr	neg	——	tr	neg	neg	tr	neg
5/26	tr	tr	+	——	neg	tr	tr	tr	tr
5/28	tr	tr	tr	——	tr	+	+	tr	+
5/31	tr	tr	+	——	tr	+	+	tr	——
6/2	——	——	——	——	——	neg	neg	tr	+
6/4	——	——	——	——	——	tr	tr	neg	tr
6/7	——	——	——	——	——	tr	neg	+	+
6/9	tr	neg	——	——	——	tr	tr	——	neg
6/10	——	——	neg	——	tr	——	——	——	——
6/11	——	——	——	——	——	tr	tr	——	+

TABLE AII. 54

FECAL FAT (SUDAN IV), Qualitative

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
J 6/12	——	1+	1+	2+	——	J 19/26	tr	2+	tr	tr
J 12/19	2+	2+	1+	2+	——	J 26/F 2	+	2+	3+	+
J 19/26	1+	1+	tr	neg	——	F 2/9	——	——	tr	——
J 26/F 2	1+	2+	1+	neg	——	F 2/10	tr	——	——	——
F 2/9	tr	1+	1+	1+	1+	F 2/16	tr	——	——	1+
F 9/26	——	——	——	——	1+	F 9/16	tr	——	1+	1+
F 9/16	——	tr	1+	——	——	F 10/16	——	1+	——	——
F 9/28	tr	——	——	——	——	F 16/23	+	neg	2+	1+
F 16/23	——	1+	——	——	——	F 23/M 2	——	2+	2+	2+
F 16/26	——	——	neg	——	——	F 23/M 16	tr	——	——	——
F 26/M 2	——	——	str	——	neg	M 2/9	——	neg	neg	——
F 28/M 2	str	——	——	——	——	M 9/16	——	——	——	1+
M 2/3	+	——	——	——	——	M 16/23	2+	3+	3+	1+
F 23/M 9	——	tr	——	——	——	M 23/30	——	——	1+	1+
M 2/9	——	——	+	——	2+	M 23/A 13	1+	2+	——	——
M 3/9	tr	——	——	——	——	M 30/A 6	——	——	2+	1+
M 9/16	1+	2+	2+	——	1+	A 6/13	——	——	2+	1+

STAT

STAT

TABLE AII: 54 (contd)

Date 1953	Subject No. 1	2	3	4	12
M 16/23	—	tr	2+	—	2+
M 16/A 6	1+	—	—	—	—
M 23/30	—	neg	2+	—	tr
M 30/A 6	—	2+	—	—	1+
A 6/13	—	1+	2+	—	2+
A 13/20	—	tr	—	—	tr
A 13/27	—	—	3+	—	—
A 6/25	2+	—	—	—	—
A 20/27	—	tr	—	—	—
A 23/27	—	—	—	—	2+
A 25/27	2+	—	—	—	—
A 27/My 4	3+	1+	4+	—	2+
My 4/11	1+	2+	2+	—	3+
My 11/18	—	1+	—	—	—
My 18/25	—	2+	—	—	—
My 11/25	tr	—	tr	—	tr
My 25/Ju 1	tr	tr	tr	—	tr

Date 1953	Subject No. 5	6	7	8
A 13/20	tr	tr	2+	1+
A 20/27	—	—	2+	2+
A 20/My 4	2+	2+	—	—
A 27/My 4	—	—	neg	—
A 27/My 11	—	—	—	neg
My 4/11	tr	2+	tr	—
My 11/18	2+	2+	2+	1+
My 18/24	1+	3+	3+	tr
My 25/Ju 1	2+	3+	tr	tr
Ju 1/8	2+	2+	—	tr
Ju 1/5	—	—	neg	—
Ju 8/11	tr	2+	—	tr

TABLE AII. 55.

FECAL BENZIDINE REACTION, Qualitative

Date 1953	Subject No. 1	2	3	4	12
J 6/12	—	3+	1+	tr	—
J 12/19	2+	1+	2+	3+	—
J 19/26	3+	1+	tr	neg	—
J 26/F 2	2+	1+	1+	neg	—
F 2/9	2+	tr	tr	1+	3+
F 9/28	1+	—	—	—	—
F 9/16	—	neg	2+	—	—
F 16/23	—	neg	—	—	—
F 9/26	—	—	—	—	1+
F 16/26	—	—	neg	—	—
F 26/M 2	—	—	str	—	0
F 28/M 2	tr	—	—	—	—
M 2/3	tr	—	—	—	—
F 23/M 9	—	tr	—	—	—
M 2/9	—	—	3+	—	3+
M 3/9	tr	—	—	—	—
M 9/16	3+	tr	1+	—	2+

Date 1953	Subject No. 5	6	7	8
J 19/26	2+	3+	tr	2+
J 26/F 2	+	2+	t r	+
F 2/9	—	—	neg	—
F 2/10	—	neg	—	—
F 2/16	tr	—	—	neg
F 9/16	tr	—	neg	neg
F 10/16	—	tr	—	—
F 16/23	+	tr	neg	2+
F 23/M 2	—	2+	+	2+
F 23/M 16	str	—	—	—
M 2/9	—	neg	neg	—
M 9/16	—	neg	neg	—
M 2/16	—	—	—	neg
M 16/23	3+	2+	0	3+
M 23/30	—	—	str	3+
M 23/A 13	tr	neg	—	—
M 30/A 6	—	—	tr	3+

TABLE AII. 55 (contd)

Date 1953	Subject No. 1	2	3	4	12
M 16/23	—	1+	2+	—	3+
M 16/A 6	tr	—	—	—	—
M 23/30	—	str	1+	—	3+
M 30/A 6	—	str	—	—	2+
A 6/13	—	2+	1+	—	2+
A 13/20	—	neg	—	—	neg
A 13/27	—	—	neg	—	—
A 6/25	4+	—	—	—	—
A 20/27	—	neg	—	—	—
A 23/27	—	—	—	—	3+
A 25/27	1+	—	—	—	—
A 27/My 4	tr	tr	neg	—	3+
My 4/11	4+	2+	tr	—	2+
My 11/18	—	neg	—	—	—
My 18/25	—	neg	—	—	—
My 11/25	neg	—	neg	—	neg
My 25/Ju 1	2+	tr	tr	—	2+

Date 1953	Subject No. 5	6	7	8
A 6/13	—	—	tr	3+
A 13/20	tr	neg	neg	3+
A 20/27	—	—	3+	3+
A 20/My 4	tr	tr	—	—
A 27/My 4	tr	tr	neg	—
A 27/My 11	—	—	—	neg
My 4/11	tr	1+	neg	—
My 11/18	1+	tr	neg	2+
My 18/24	3+	1+	tr	2+
My 25/Ju 1	3+	2+	neg	neg
Ju 1/8	3+	2+	—	neg
Ju 1/5	—	—	neg	—
Ju 8/11	2+	1+	—	tr

TABLE AII. 56

MEAT FIBERS IN FECES, Qualitative

Date 1953	Subject No. 1	2	3	4	12
J 6/12	—	2	1	1	—
J 12/19	4	4	2	5-6	—
J 19/26	4	4-6	3	3	—
J 26/F 2	2	3	4-5	2	—
F 2/9	2	3-4	4-5	1	4-5
F 9/26	—	—	—	—	4-5
F 9/16	—	4-5	2-3	—	—
F 9/28	1	—	—	—	—
F 16/23	—	2-3	—	—	—
F 16/26	—	—	2-3	—	—
F 26/M 2	—	—	3	—	4
F 28/M 2	4	—	—	—	—
M 2/3	1	—	—	—	—
F 23/M 9	—	10	—	—	—
M 2/9	—	—	6	—	7-8
M 3/9	6-7	—	—	—	—

Date 1953	Subject No. 5	6	7	8
J 19/26	3-5	4-6	8	6
J 26/F 2	2	4-5	6-8	5-6
F 2/9	—	—	6-8	—
F 2/10	—	1	—	—
F 2/16	3-4	—	—	10-12
F 9/16	—	—	10-12	—
F 10/16	—	3-4	—	—
F 16/23	3-4	4-5	8-10	6-7
F 23/M 2	—	6-7	12-15	7-8
F 23/M 16	20-25	—	—	—
M 2/9	—	1	5-7	—
M 9/16	—	10-15	10-12	—
M 2/16	—	—	—	5
M 16/23	8-9	1-2	2	7-8
M 23/30	—	—	15-16	15-20
M 23/A 13	5-6	8-10	—	—

STAT
STAT

TABLE AII. 56 (ccntd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
M 9/16	5	4-5	5-6	-	9-10	M 30/A 6	-	-	15-20	10-12
M 16/23	-	1	8-10	-	15-20	A 6/13	-	-	25-30	8-10
M 16/A 6	6-7	-	-	-	-	A 13/20	15-20	10-16	10-15	8-10
M 23/30	-	15-20	10-12	-	8-10	A 20/27	-	-	10-12	12-15
M 30/A 6	-	4-5	-	-	8-10	A 20/My 4	8-10	15-17	-	-
A 6/13	-	4-5	3-4	-	15-20	A 27/My 11	-	-	5-6	-
A 13/20	-	-	-	-	4-5	A 27/My 11	-	-	-	15-20
A 13/27	-	-	1	-	-	My 4/11	8-10	10-12	-	-
A 6/25	5	-	-	-	-	My 11/18	10-15	10-15	10-12	10-20
A 20/27	-	8-10	-	-	-	My 18/24	5-6	10-15	20-25	8-10
A 23/27	-	-	-	-	7-8	My 25/Ju 1	8-10	8-10	35-40	10-15
A 25/27	7-8	-	-	-	-	Ju 1/8	10-12	10-12	-	15-20
A 27/My 4	6-7	3-4	3	-	7-8	Ju 1/5	-	-	8-10	-
My 4/11	10-12	5-6	5-8	-	12-15	Ju 8/11	5-6	5-6	-	10-12
My 11/18	-	2	-	-	-					
My 18/25	-	10-12	-	-	-					
My 11/25	2-3	-	-	-	3-4					
My 25/Ju 1	8-10	5-6	5-8	-	8-10					

TABLE AII. 57

DAILY BODY WEIGHT, kg

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/5	69.4	69.8	83.9	82.7					
1/6	69.7	70.3	83.9	82.7					
1/7	70.0	70.6	83.8	82.7					
1/8	70.4	70.7	83.8	83.0					
1/9	70.3	70.4	83.6	82.9					
1/10	69.7	70.6	83.0	82.5					
1/11	70.0	70.3	83.2	82.7					
1/12	69.6	70.8	83.6	82.9					
1/13	69.4	70.8	83.0	82.9					
1/14	70.1	71.1	82.5	82.9					
1/15	71.1	71.1	82.5	82.9					
1/16	70.4	70.8	83.0	83.0					
1/17	70.2	70.2	83.0	82.3					
1/18	70.2	70.4	82.6	82.5					
1/19	70.2	70.2	81.5	82.5					
1/20	69.1	70.7	80.3	81.6					
1/21	68.4	71.1	79.5	81.1					
1/22	68.2	70.6	79.4	80.5					
1/23	67.1	70.3	79.4	80.0					
1/24	67.1	70.4	78.9	79.6					
1/25	67.0	70.4	78.9	79.4					
1/26	67.1	70.2	79.0	79.4					
1/27	67.2	70.1	77.6	79.4					
1/28	67.0	70.7	79.5	79.0					
1/29	67.4	70.5	80.7	79.4					
1/30	67.5	70.3	81.6	79.6					
1/31	67.5	70.3	81.1	79.3					
2/1									

STAT

TABLE AII. 57 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
2/1	70.6	71.1	81.8	79.2	--	65.9	64.6	66.7	65.4
2/3	69.8	71.2	--	80.9	--	64.4	62.9	64.4	64.1
2/4	68.9	71.2	--	80.6	--	63.9	61.6	63.5	63.6
2/5	69.5	71.2	79.8	81.2	--	62.1	60.6	62.0	62.5
2/6	58.7	71.2	80.2	81.2	--	61.4	60.0	61.2	62.0
2/7	68.9	70.7	80.9	81.1	--	60.9	58.9	60.5	61.5
2/8	68.5	70.4	81.0	81.2	--	60.5	58.3	59.7	61.0
2/9	69.8	70.6	81.1	--	74.6	59.7	58.2	59.5	60.6
2/10	69.1	71.3	80.2	--	73.8	62.5	57.5	59.0	60.0
2/11	69.3	71.5	79.7	--	73.8	63.9	56.6	58.5	62.4
2/12	69.8	72.0	80.9	--	73.5	64.1	58.9	57.9	65.0
2/13	70.5	71.6	80.7	--	73.9	63.9	60.8	59.2	66.6
2/14	69.8	71.5	80.7	--	73.9	63.9	62.0	61.0	67.5
2/15	69.6	70.7	79.4	--	73.8	63.9	62.2	63.4	66.5
2/16	69.4	71.4	80.9	--	73.9	64.4	61.8	64.2	66.6
2/17	68.1	70.2	78.9	--	72.5	64.4	62.4	64.3	67.0
2/18	67.3	69.2	77.6	--	70.5	64.8	62.5	64.4	67.0
2/19	66.1	68.0	77.0	--	70.3	65.2	62.5	64.3	67.0
2/20	65.5	67.0	76.5	--	69.3	65.6	63.1	65.1	67.1
2/21	65.2	65.9	76.1	--	68.4	65.5	63.3	65.7	67.5
2/22	64.4	65.3	74.4	--	67.8	65.6	63.9	66.1	67.0
2/23	64.1	65.0	74.2	--	67.4	65.9	63.8	66.8	67.7
2/24	63.7	64.1	73.8	--	66.6	64.6	63.1	66.1	67.9
2/25	63.5	63.7	73.4	--	66.4	65.9	63.5	66.1	68.1
2/26	62.5	63.4	75.4	--	69.3	65.2	63.4	65.4	67.7
2/27	62.6	62.9	75.0	--	72.0	65.5	63.6	65.9	68.1
2/28	65.5	62.3	76.8	--	73.9	65.5	63.6	66.1	68.0
3/1	65.6	61.8	76.1	--	73.0	64.8	--	65.6	67.5
3/2	67.5	61.6	77.0	--	73.5	65.4	64.2	66.5	67.5
3/3	68.0	63.8	77.0	--	74.8	65.8	62.7	64.5	66.8

391

TABLE AII. 57 (contd)

Date	Subject No.								
1953	1	2	3	12	5	6	7	8	
3/4	68.6	66.5	76.9	73.6	63.5	61.6	63.5	65.5	
3/5	68.4	67.0	77.1	73.8	63.2	61.2	61.6	65.2	
3/6	68.0	67.7	77.7	73.8	62.7	60.7	61.0	64.6	
3/7	68.4	67.9	77.5	73.8	61.8	60.2	60.6	64.3	
3/8	67.5	68.4	77.3	73.5	61.5	59.8	59.7	64.1	
3/9	67.5	68.9	77.5	74.4	61.4	59.3	59.5	63.9	
3/10	68.3	68.9	78.0	75.6	60.9	59.6	59.5	--	
3/11	69.2	69.5	78.4	75.4	60.6	59.2	59.5	63.3	
3/12	68.0	68.9	77.5	73.9	60.9	58.9	59.3	63.3	
3/13	69.6	69.5	77.7	74.5	60.5	56.9	59.3	63.0	
3/14	69.4	69.3	78.6	74.6	60.0	57.9	58.5	62.9	
3/15	68.9	68.9	78.6	74.3	62.3	59.6	59.4	62.3	
3/16	69.1	69.5	79.1	73.9	64.1	61.9	59.5	62.3	
3/17	68.0	68.1	77.7	73.9	64.5	62.1	61.7	66.3	
3/18	66.4	67.2	77.0	73.9	65.2	63.0	64.6	66.8	
3/19	65.4	66.5	76.8	73.7	65.5	63.0	64.8	66.8	
3/20	65.0	66.1	77.0	74.0	65.4	63.2	64.6	66.5	
3/21	64.6	65.6	76.5	73.5	65.5	63.0	66.7	69.5	
3/22	64.3	65.3	76.1	73.7	64.4	63.2	65.8	68.1	
3/23	64.1	65.4	76.4	73.5	65.3	64.1	67.3	69.3	
3/24	64.3	65.3	76.4	73.8	65.6	63.5	67.0	69.3	
3/25	64.2	65.3	76.4	74.1	65.0	63.9	67.4	69.6	
3/26	64.4	65.2	76.1	73.2	65.0	63.5	67.1	69.5	
3/27	64.5	64.7	76.1	73.5	64.8	64.5	67.1	69.5	
3/28	64.4	64.6	75.6	73.6	64.8	64.2	67.5	70.2	
3/29	64.5	64.6	75.2	73.4	64.1	64.3	66.8	69.3	
3/30	66.0	65.8	76.1	74.1	64.7	64.4	67.5	69.6	
3/31	68.1	67.3	77.1	75.2	65.6	65.2	67.1	69.3	
4/1	69.3	68.3	77.8	74.6	62.6	61.5	67.0	68.8	
4/2	70.0	69.4	--	74.6	62.0	60.7	67.1	66.4	
4/3	70.1	--	--	74.5	61.6	60.6	66.6	68.2	
4/4	--	69.4	--	75.1	61.4	60.1	--	67.9	

392

STAT
STAT

Declassified in Part - Sanitized Copy Approved for Release @ 50-Yr 2014/02/19 : CIA-RDP81-01043R003700220001-2

TABLE AII. 57 (contd)

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
4/5	—	70.5	—	75.4	60.9	59.7	66.1	67.9
4/6	69.5	70.2	78.9	75.7	60.6	59.3	67.1	67.9
4/7	68.9	70.5	79.1	75.9	59.8	58.4	66.5	67.8
4/8	70.2	70.3	79.0	76.0	59.7	58.1	66.1	68.0
4/9	69.9	70.3	79.7	75.7	60.6	58.1	66.5	68.3
4/10	70.1	70.7	80.3	75.9	60.4	57.9	66.5	68.6
4/11	69.1	71.1	79.8	75.3	60.2	57.5	66.2	68.1
4/12	70.2	70.7	79.4	75.6	59.5	57.4	65.6	68.0
4/13	69.3	70.3	78.8	76.2	59.5	57.9	66.1	68.9
4/14	68.4	68.9	77.4	74.6	62.5	61.1	67.1	69.6
4/15	67.5	68.0	75.9	73.2	63.0	62.5	67.9	69.2
4/16	67.4	67.4	75.6	72.5	63.9	63.0	68.1	68.9
4/17	66.5	67.0	75.5	72.0	64.3	62.7	68.4	69.5
4/18	64.2	66.5	76.0	72.0	64.5	63.6	68.9	69.6
4/19	65.9	66.2	75.6	71.6	64.5	—	68.9	69.8
4/20	66.1	65.9	77.1	71.6	64.6	63.9	69.5	70.2
4/21	66.2	65.2	77.0	71.2	64.8	64.4	70.3	70.5
4/22	66.0	65.2	76.2	70.3	64.3	64.8	70.1	70.6
4/23	65.7	64.8	76.9	69.1	—	65.0	69.4	70.6
4/24	65.6	64.6	76.9	72.7	64.1	64.8	70.2	70.5
4/25	65.8	64.5	76.1	75.2	65.0	65.6	70.5	70.5
4/26	65.4	64.3	75.5	74.4	65.0	—	70.0	69.8
4/27	65.7	65.0	76.4	74.5	65.6	65.2	70.5	70.3
4/28	68.4	66.5	77.6	73.7	63.4	63.6	68.4	68.9
4/29	69.4	68.8	78.3	73.5	62.8	62.6	67.5	68.1
4/30	68.6	68.0	77.2	74.3	62.4	62.2	66.8	68.0
5/1	69.3	69.2	77.0	74.1	62.0	61.4	65.9	67.3
5/2	68.4	68.8	77.2	74.1	61.3	61.0	65.6	66.6
5/3	68.4	69.3	78.0	74.2	60.9	60.8	65.2	66.5
5/4	69.5	69.2	78.5	74.1	60.6	61.3	64.8	66.1

TABLE AII. 57 (contd).

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
5/5	69.4	69.7	80.5	74.5	60.2	61.1	64.4	66.1
5/6	69.5	70.4	78.9	74.3	60.6	61.3	63.9	65.8
5/7	70.6	69.6	—	74.8	61.4	61.6	63.6	65.6
5/8	—	68.6	78.9	74.1	63.1	62.7	63.3	65.3
5/9	70.1	68.9	78.4	73.0	63.6	63.5	62.9	65.2
5/10	69.1	69.1	78.6	73.9	63.6	63.0	62.9	64.5
5/11	70.1	69.3	79.4	74.6	64.5	63.0	62.9	64.3
5/12	68.3	68.3	77.9	73.5	63.3	63.6	65.0	65.6
5/13	67.5	68.3	77.5	72.9	63.2	63.5	66.3	67.0
5/14	67.2	67.7	77.0	72.5	63.6	63.9	66.5	65.9
5/15	67.0	67.4	76.4	71.8	63.4	63.6	67.1	68.8
5/16	66.6	66.4	76.0	71.1	63.1	63.9	67.6	68.6
5/17	65.9	66.5	75.9	71.4	63.2	64.5	69.4	—
5/18	65.4	66.6	75.7	71.1	63.3	65.0	67.5	66.2
5/19	65.6	66.1	74.8	71.0	63.3	64.8	67.2	68.2
5/20	65.6	66.4	74.4	70.6	63.6	64.5	67.5	68.4
5/21	65.6	65.9	74.4	70.1	63.6	65.0	68.6	—
5/22	65.4	65.9	74.1	70.0	63.6	64.6	65.0	66.2
5/23	65.2	65.3	73.8	70.0	63.8	65.3	64.4	68.2
5/24	65.0	67.0	73.8	70.0	63.1	64.1	67.6	67.7
5/25	64.5	67.7	73.9	69.6	63.4	64.8	67.0	67.7
5/26	67.5	68.4	77.6	72.9	63.3	63.3	66.6	66.6
5/27	68.1	68.6	78.6	73.6	63.6	62.2	66.6	65.7
5/28	68.0	68.4	78.4	74.9	63.0	62.2	66.6	65.9
5/29	68.9	67.7	78.1	74.3	63.9	61.6	66.2	66.1
5/30	67.0	68.2	78.0	73.6	64.1	60.9	66.2	66.1
5/31	67.2	68.0	78.6	74.5	66.6	63.6	65.3	66.1
6/1	68.5	67.9	79.4	73.8	66.6	64.3	65.6	66.5
6/2	—	—	—	—	67.0	64.1	65.5	66.5

STAT
STAI

Declassified in Part - Sanitized Copy Approved for Release @ 50-Yr 2014/02/19 : CIA-RDP81-01043R003700220001-2

TABLE AII. 57 (contd)

Date 1953	Subject No. 1	2	3	12	5	6	7	8
6/3					66.5	64.1	—	68.6
6/4					66.5	63.9	64.8	68.4
6/5					65.4	64.1	65.2	68.4
6/6					66.9	64.7	64.6	68.1
6/7					66.9	64.3	64.6	65.6
6/8					67.7	64.8	65.2	68.1
6/9					67.3	64.6	—	65.9
6/10			61.4	73.6	66.8	64.4	—	68.8
6/11					66.9	64.6	—	66.9
6/12					67.0	65.2	—	66.5
6/13	69.0	69.9			66.6	64.3	—	65.9

TABLE AII. 58

ORIGINAL DATA FOR ANTIPYRINE SPACE AND WATER DIURESIS TEST

Subject No.	Date	Weight kg Normal*	Weight kg Test Day	Antipyrine Space (Total body water) l	Antipyrine Space (Total body water) % Body wt	Per Cent Recovery of Oral Load Corrected **	Per Cent Recovery of Oral Load Uncorrected
1	25 April	69.6	65.8	40.0	61.2	51.0	55.4
	9 May		70.1	33.9	47.8	77.0	98.0
2	28 Feb.	70.2	62.2	30.0	48.3	7.8	14.5
	25 April		64.5	36.6	56.8	10.7	15.0
	30 May		66.4	37.9	55.4	—	—
3	23 May	80.1	74.0	33.1	44.8	15.7	33.0
12	2 Feb.	74.7	71.8	39.6	55.3	—	—
	27 Mar.		73.4	36.6	49.8	68.0	78.0
	23 May		70.0	42.0	60.0	65.0	68.0
5	8 Feb.	65.3	65.0	39.4	60.5	68.0	—
	11 April		66.4	32.8	49.4	24.0	28.0
	5 June		66.5	33.4	50.0	72.0	79.0
6	11 April	64.3	57.5	26.1	49.1	7.0	12.0
	11 June		64.5	37.5	58.0	91.0	103.0
7	9 May	67.4	63.0	29.6	47.0	14.0	16.0
	24 May		68.4	47.3	69.0	—	—
8	9 May	68.3	65.3	28.1	43.0	42.0	46.0
	11 June		67.0	38.2	57.0	—	—
9	17 May	66.3	64.5	33.2	51.5	0.0	10.0
	31 May		64.1	32.3	50.3	56.2	73.0
	13 June		66.3	35.6	53.7	—	—
10	4 April	77.3	73.5	31.1	42.5	0.0	6.6
	2 May		77.3	37.9	49.0	80.0	85.0
11	4 April	64.8	61.6	26.3	42.7	24.0	34.9
	16 April		61.0	24.1	39.4	0.8	15.0
	2 May		64.8	33.6	51.8	60.3	68.2
	17 May		62.0	38.3	61.7	2.2	90.2
	31 May		60.4	25.8	42.8	2.0	11.0
AAP	4 April	83.0	79.5	31.8	40.0	13.2	40.5
	2 May		83.0	38.6	46.5	59.0	70.6

*Normal weight: average of all pre-period average weights.

**Load recovery = 100 {urine output (0830-1230) - ½ [urine output (0730-0830)]} /oral dose.

STAT

TABLE AII. 59

RESTING PULMONARY VENTILATION, l/min

Date	Subject No.					Date	Subject No.				
1953	1	2	3	4	12	1953	5	6	7	8	
1/8	--	--	--	9.44	--	1/23	6.20	10.6	6.52	7.26	
1/9	--	6.66	6.41	--	--	1/29	--	8.44	--	--	
1/10	5.30	--	--	--	--	1/30	6.08	--	6.61	--	
1/15	--	--	--	9.43	--	1/31	--	--	--	8.04	
1/16	4.86	6.24	6.98	--	--	2/6	5.55	7.03	--	--	
1/22	5.24	7.01	--	7.56	--	2/9	--	--	--	5.61	
1/23	--	--	6.51	--	--	2/10	--	7.34	--	--	
1/26	--	--	6.51	--	--	2/11	--	--	6.78	--	
1/29	--	--	--	8.29	--	2/13	5.41	8.44	5.12	5.57	
1/30	4.76	--	--	--	--	2/20	5.77	8.06	7.15	6.43	
1/31	--	6.50	--	--	--	2/27	5.22	8.00	6.10	5.93	
2/5	6.01	6.56	7.71	6.88	7.34	3/6	4.71	5.74	6.08	5.40	
2/12	4.58	9.49	6.69	--	7.82	3/9	--	--	6.45	--	
2/19	4.58	5.90	5.65	--	6.05	3/13	3.33	4.95	5.26	4.18	
2/24	--	--	--	--	--	3/20	6.08	6.49	7.02	7.10	
2/26	3.58	5.34	--	--	--	3/27	5.55	10.10	7.61	4.35	
3/5	5.72	4.95	7.92	--	6.94	4/3	3.09	5.06	6.40	6.55	
3/12	5.92	7.00	7.53	--	6.66	4/10	5.01	4.96	6.05	5.77	
3/19	5.76	5.30	7.92	--	8.61	4/17	6.14	8.33	6.24	6.06	
3/26	4.50	5.79	6.68	--	7.92	4/24	6.53	7.76	6.88	6.47	
4/2	5.96	7.44	--	--	6.01	5/1	5.25	5.80	5.29	5.94	
4/8	--	--	--	--	6.96	5/6	4.73	7.05	--	--	
4/9	5.71	4.84	7.43	--	--	5/8	--	--	5.57	5.25	
4/16	4.56	4.16	6.65	--	5.46	5/15	7.97	8.20	7.04	5.74	
4/21	--	--	--	--	5.15	5/22	6.30	7.24	6.37	7.44	
4/23	4.39	4.23	5.30	--	--	5/29	6.48	9.86	6.06	6.21	
4/30	5.27	4.76	8.31	--	5.84	6/4	--	--	5.54	--	
5/5	--	7.24	8.55	--	--	6/5	6.14	6.55	--	6.38	
5/7	6.40	--	--	--	5.65	6/12	--	--	--	--	
5/14	5.59	5.30	6.24	--	5.37						
5/21	5.40	--	5.64	--	5.53						
5/28	5.57	6.57	8.80	--	7.26						

TABLE AII. 60

RESTING OXYGEN CONSUMPTION, ml/min

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/8	--	--	--	294	--	1/23	280	318	284	277
1/9	--	306	276	--	--	1/29	--	341	--	--
1/10	281	--	--	--	--	1/30	316	--	330	--
1/15	--	--	--	284	--	1/31	--	--	--	306
1/16	242	304	249	--	--	2/6	275	281	--	--
1/22	218	317	--	262	--	2/9	--	--	--	239
1/23	--	--	320	--	--	2/10	--	249	--	--
1/27	--	--	284	--	--	2/11	--	--	258	--
1/30	274	--	--	286	--	2/13	272	347	252	268
1/31	--	304	--	--	--	2/20	313	343	336	322
2/5	306	334	351	313	308	2/27	282	322	287	293
2/12	258	370	319	--	336	3/6	228	239	262	248
2/19	224	253	246	--	213	3/9	--	--	--	--
2/24	--	--	264	--	284	3/13	194	205	248	227
2/26	204	253	--	--	--	3/20	316	295	331	316
3/5	281	248	315	--	327	3/27	281	340	344	209
3/12	290	305	323	--	316	4/3	197	237	242	278
3/19	292	218	320	--	311	4/10	236	216	276	269
3/26	259	304	304	--	314	4/17	295	336	296	282
4/2	265	328	--	--	282	4/24	326	365	322	284
4/8	--	--	--	--	322	5/1	271	251	253	240
4/9	270	258	346	--	--	5/6	233	275	--	--
4/16	239	226	294	--	260	5/8	--	--	231	234
4/21	--	--	--	--	295	5/15	358	354	313	276
4/23	218	233	271	--	--	5/22	286	287	292	283
4/30	251	262	358	--	267	5/29	263	325	278	252
5/5	--	313	334	--	--	6/4	--	--	242	--
5/7	296	--	--	--	268	6/5	277	291	--	241
5/14	246	262	283	--	243	6/12	333	334	--	297
5/21	231	--	238	--	245					
5/28	244	297	306	--	321					

STAT

TABLE AII. 61

RESTING RESPIRATORY QUOTIENT

Date	Subject No.					Date	Subject No.				
1953	1	2	3	4	12	1953	5	6	7	8	
1/8	—	—	—	1.13	—	1/23	0.86	1.09	0.82	0.91	
1/9	—	0.92	0.86	—	—	1/29	—	0.91	—	—	
1/10	0.78	—	—	—	—	1/30	0.83	—	0.82	—	
1/15	—	—	—	0.91	—	1/31	—	—	—	0.97	
1/16	0.78	0.87	0.82	—	—	2/6	0.71	0.74	—	—	
1/22	0.88	0.92	—	0.92	—	2/9	—	—	—	0.77	
1/23	—	—	0.80	—	—	2/10	—	0.79	—	—	
1/27	—	—	0.84	—	—	2/11	—	—	0.80	—	
1/29	0.74	—	—	—	—	2/13	0.79	0.80	0.77	0.86	
1/30	—	—	—	0.95	—	2/20	0.81	0.98	0.84	0.82	
1/31	—	0.86	—	—	—	2/27	0.79	0.96	0.83	0.84	
2/5	0.85	0.89	0.89	0.77	0.92	3/6	0.76	0.76	0.78	0.74	
2/12	0.72	0.95	0.85	—	0.88	3/9	—	—	0.75	—	
2/19	0.86	0.80	0.94	—	0.99	3/13	0.70	0.78	0.81	0.67	
2/24	—	—	0.74	—	0.65	3/20	0.88	0.90	0.93	0.97	
2/26	0.75	0.68	—	—	—	3/27	0.78	0.99	0.94	0.91	
3/5	0.83	0.83	0.94	—	0.91	4/3	0.69	0.71	0.86	0.92	
3/12	0.82	0.94	0.91	—	0.86	4/10	0.76	0.75	0.82	0.84	
3/19	0.73	0.96	0.92	—	0.95	4/17	0.88	0.97	0.84	0.87	
3/26	0.70	0.68	0.82	—	0.92	4/24	0.89	0.94	0.82	0.92	
4/2	0.84	0.92	—	—	0.83	5/1	0.79	0.76	0.79	0.92	
4/8	—	—	—	—	0.89	5/6	0.74	0.80	—	—	
4/9	0.82	0.80	0.89	—	—	5/8	—	—	0.83	0.82	
4/16	0.69	0.70	0.77	—	0.79	5/16	0.89	0.88	0.85	0.81	
4/21	—	—	—	—	0.68	5/22	0.88	0.79	0.86	0.92	
4/22	0.72	0.74	0.79	—	—	5/29	0.88	1.01	0.82	0.88	
4/30	0.81	0.85	0.90	—	0.90	6/4	—	—	0.79	—	
5/5	—	0.98	0.96	—	—	6/5	0.82	0.84	—	0.91	
5/7	0.88	—	—	—	0.78	6/12	0.85	0.92	—	0.88	
5/14	0.84	0.80	0.82	—	0.83						
5/21	0.85	—	0.84	—	0.88						
5/28	0.76	0.89	1.5	—	0.88						

TABLE AII. 62

RESTING INSENSIBLE WATER LOSS, gm/hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/8	—	—	—	70.1	—	1/23	58.9	36.7	38.6	43.5
1/9	46.7	47.6	62.3	—	—	1/29	—	38.2	47.5	—
1/15	—	—	—	80.5	—	1/30	67.1	—	—	—
1/16	37.2	29.2	47.2	—	—	1/31	—	—	—	36.1
1/22	35.4	63.3	—	67.8	—	2/6	43.9	36.8	37.5	33.9
1/23	—	—	50.1	—	—	2/9	—	—	—	26.4
1/27	—	—	41.0	—	—	2/10	—	18.5	—	—
1/30	28.9	—	—	45.0	—	2/11	—	—	28.9	—
1/31	—	67.1	—	—	—	2/13	61.5	40.3	59.7	43.6
2/5	21.5	52.4	52.5	56.8	44.3	2/20	34.9	49.7	74.0	31.0
2/12	42.1	55.9	80.8	—	43.4	2/27	77.6	34.2	45.4	34.8
2/19	29.1	23.0	42.6	—	35.3	3/6	33.4	23.3	29.9	16.9
2/24	—	—	37.9	—	35.2	3/9	—	—	28.7	—
2/26	28.0	29.1	—	—	—	3/13	40.3	28.5	29.6	40.6
3/5	32.3	21.4	30.5	—	41.6	3/20	35.7	32.9	36.7	34.0
3/12	54.4	80.8	65.2	—	51.1	3/27	48.9	31.6	36.4	35.2
3/19	31.5	44.5	42.1	—	41.6	4/3	48.5	36.5	36.7	35.9
3/26	29.3	35.9	32.6	—	41.3	4/10	36.2	25.9	43.6	40.2
4/2	30.1	45.9	—	—	36.0	4/17	39.2	31.5	47.4	32.2
4/8	—	—	—	—	49.4	4/24	30.9	24.6	45.1	37.5
4/9	35.3	66.2	78.4	—	—	5/1	33.6	36.3	23.5	27.5
4/16	25.3	50.8	37.7	—	38.2	5/6	38.2	22.8	—	—
4/21	—	—	—	—	43.9	5/8	—	—	36.0	44.5
4/23	26.9	38.4	37.3	—	—	5/15	69.7	37.3	33.5	34.5
4/30	25.9	46.9	49.5	—	26.9	5/22	32.2	30.7	45.0	34.4
5/5	—	54.6	45.9	—	—	5/29	52.8	22.1	41.0	36.9
5/7	48.1	—	—	—	57.4	6/4	—	—	30.2	—
5/14	35.9	36.2	30.9	—	33.1	6/5	59.0	23.3	—	21.6
5/21	25.3	25.2	34.8	—	32.4	6/12	84.8	33.8	—	59.5
5/28	40.7	46.0	76.8	—	91.0					

TABLE AII. 63

RESTING PULMONARY WATER LOSS, gm/hr.

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/8	—	—	—	28.8	—	1/23	18.5	32.2	19.5	21.8
1/9	16.1	20.2	19.5	—	—	1/29	—	23.4	19.8	—

TABLE AII. 63 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/15	----	----	----	28.8	----	1/30	18.2	----	----	----
1/16	14.7	18.9	20.2	----	----	1/31	----	----	----	24.0
1/22	15.9	21.3	----	23.4	----	2/6	15.6	20.9	----	----
1/23	----	----	19.5	----	----	2/9	----	----	----	16.6
1/27	----	----	19.5	----	----	2/11	----	----	20.3	----
1/30	14.2	----	----	24.8	----	2/13	16.2	25.0	15.7	16.7
1/31	----	19.5	----	----	----	2/20	17.2	24.3	21.5	19.3
2/5	18.0	19.6	23.2	20.6	22.0	2/27	13.8	23.9	18.3	17.8
2/12	13.7	28.5	19.8	----	22.6	3/6	14.1	17.2	18.0	16.1
2/19	13.7	17.6	15.8	----	17.4	3/9	----	----	19.5	----
2/24	----	----	16.7	----	16.9	3/13	10.0	14.9	15.9	12.6
2/26	11.9	16.1	----	----	----	3/20	18.2	16.6	21.0	21.3
3/5	17.1	14.8	23.6	----	20.8	3/27	16.5	30.4	22.8	11.2
3/12	17.8	21.0	22.4	----	20.3	4/3	9.2	15.3	19.2	19.8
3/19	17.3	15.9	23.6	----	25.7	4/10	15.0	14.7	18.2	17.2
3/26	13.5	17.2	20.0	----	23.7	4/17	18.2	24.9	18.4	18.0
4/2	21.4	22.2	----	----	17.9	4/24	19.6	23.2	20.6	19.3
4/8	----	----	----	----	20.9	5/1	15.7	17.3	15.8	17.7
4/9	17.2	14.6	22.1	----	----	5/6	14.4	21.1	----	----
4/16	13.6	12.4	19.8	----	16.3	5/8	----	----	16.8	15.7
4/21	----	----	----	----	15.5	5/15	24.0	24.6	21.1	17.2
4/23	13.1	12.7	15.8	----	----	5/22	18.8	18.8	19.1	22.3
4/30	15.8	14.3	25.1	----	17.5	5/29	19.0	----	18.2	18.7
5/5	----	21.7	25.6	----	----	6/4	----	----	16.6	----
5/7	19.3	----	----	----	17.0	6/5	18.5	19.7	----	19.1
5/14	17.1	15.9	18.8	----	16.1	6/12	19.1	25.8	----	19.6
5/21	16.1	11.7	18.0	----	16.6					
5/28	17.1	20.1	26.8	----	22.2					

TABLE AII. 64

RESTING CUTANEOUS WATER LOSS, gm/hr

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/8	----	----	----	41.5	----	1/23	40.4	4.5	19.1	21.7
1/9	30.6	27.4	42.8	----	----	1/29	----	14.8	27.7	----
1/15	----	----	----	----	----	1/30	18.9	----	----	12.1
1/16	23.8	10.3	27.0	51.7	----	1/31	----	----	----	----
1/22	19.5	42.0	----	44.2	----	2/6	29.3	15.9	----	----

TABLE AII. 64 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/23	----	----	30.6	----	----	2/9	----	----	----	9.8
1/27	----	----	21.5	----	----	2/11	----	----	8.6	----
1/30	14.7	----	----	20.2	----	2/13	45.3	15.3	34.0	26.9
1/31	----	47.6	----	----	----	2/20	17.7	25.4	52.5	11.7
2/5	3.5	32.8	29.3	36.2	22.3	2/27	63.8	10.3	27.1	17.0
2/12	28.4	27.4	61.0	----	20.8	3/6	19.3	6.2	11.9	0.8
2/19	15.4	5.4	25.8	----	17.9	3/9	----	----	3.2	----
2/24	----	----	21.2	----	18.3	3/13	30.8	13.6	13.7	28.0
2/26	16.1	13.0	----	----	----	3/20	17.5	16.3	15.7	12.7
3/5	15.2	6.6	6.7	----	20.8	3/27	32.4	1.2	13.6	24.0
3/12	36.6	59.8	42.8	----	39.8	4/3	39.3	21.2	17.5	16.1
3/19	14.2	28.6	18.5	----	15.9	4/10	21.2	11.2	25.4	23.0
3/26	15.8	18.7	12.6	----	17.6	4/17	21.0	6.6	29.0	14.2
4/2	8.7	23.7	----	----	18.1	4/24	11.3	1.4	24.6	18.2
4/8	----	----	----	----	28.5	5/1	17.9	19.0	7.7	9.8
4/9	18.1	51.5	56.3	----	----	5/6	13.8	1.7	----	----
4/16	11.7	38.4	17.9	----	22.3	5/8	----	----	19.2	28.8
4/21	----	----	----	----	28.4	5/15	15.7	12.7	12.5	17.3
4/23	13.8	25.7	21.5	----	----	5/22	13.3	11.9	25.9	12.1
4/30	10.1	32.6	24.4	----	9.4	5/29	33.4	----	22.8	18.2
5/5	----	32.9	20.3	----	----	6/4	----	----	13.5	----
5/7	28.8	----	----	----	39.4	6/5	40.5	3.6	----	2.5
5/14	18.8	20.3	12.1	----	17.0	6/12	65.7	15.6	----	39.9
5/21	9.2	13.5	16.8	----	15.8					
5/28	23.6	25.9	50.9	----	68.8					

TABLE AII. 65

EXERCISE-STRESS: OXYGEN CONSUMPTION

	Subject No.	Exp Mixture	Water Intake	Period	O_2 Consumption L/Min
2/12				Pre.	1.56
2/24	3	STO	U	Exp.	1.35
2/11				Pre.	1.50
2/24	12		L	Exp.	.75
1/30				Pre.	1.16
2/11	7		U	Exp.	0.66
1/29				Pre.	0.93
2/9	8		L	Exp.	0.43

STAT
STAT

TABLE AII. 65 (contd)

Date	Subject No.	Exp Mixture	Water Intake	Period	O_2 Consumption L/Min
2/27				Pre.	1.01
3/13	5	0/100/0 1000	L	Exp.	0.58
2/26				Pre.	1.23
3/11	6		U	Exp.	0.94
2/27				Pre.	1.01
5/6	5	15/52/33 1000	L	Exp.	0.96
2/26				Pre.	1.23
5/6	6		U	Exp.	0.89
4/7				Pre.	0.64
3/23	1	30/0/70 2000	L	Exp.	0.45
4/9				Pre.	0.94
3/26	2		U	Exp.	0.66
5/5				Pre.	no data
5/20	1	0/100/0 2000	L	Exp.	no data
5/7				Pre.	0.68
5/21	2		U	Exp.	0.43
4/8				Pre.	1.68
4/22	3	2/20/78 2000	U	Exp.	1.23
4/7				Pre.	1.23
4/21	12		L	Exp.	0.90
5/20				Pre.	no data
6/4	7	15/52/33 2000	U	Exp.	0.91
5/20				Pre.	0.72
6/3	8		L	Exp.	0.65

TABLE AII. 65 (contd)

Date	Subject No.	Exp. Mixture	Water Intake	Period	O_2 Consumption L./Min.
3/26				Pre.	0.52
4/9	7	N3000	U	Exp.	0.90
3/24				Pre.	0.59
4/7	8		L	Exp.	0.54

TABLE AII. 66.

EXERCISE-STRESS: RESPIRATORY QUOTIENT

Date	Subject No.	Exp. Mixture	Water Intake	Period	R. Q.
2/12				Pre.	0.78
2/24	3	STO	U	Exp.	0.73
2/11				Pre.	0.81
2/24	12		L	Exp.	0.78
1/30				Pre.	0.94
2/11	7		U	Exp.	0.77
1/29				Pre.	0.99
2/9	8		L	Exp.	1.58
2/27				Pre.	0.85
3/13	5	0/100/0 1000	L	Exp.	0.87
2/26				Pre.	0.82
3/11	6		U	Exp.	0.82
2/27				Pre.	0.85
5/6	5	15/52/33 1000	L	Exp.	0.84
2/26				Pre.	0.82
5/6	6		U	Exp.	0.76
4/7				Pre.	0.92
3/23	1	30/0/70 2000	L	Exp.	0.73

STAT
STAI

TABLE AII. 66 (contd)

Date	Subject No.	Exp Mixture	Water Intake	Period	R. Q.
4/9				Pre.	0.90
3/26	2		U	Exp.	0.68
5/5				Pre.	no data
5/20	1	0/100/0 2000	L	Exp.	no data
5/7				Pre.	0.95
5/21	2		U	Exp.	1.85
4/8				Pre.	0.82
4/22	3	2/20/78 2000	U	Exp.	0.78
4/7				Pre.	0.67
4/21	12		L	Exp.	0.75
5/20				Pre.	no data
6/4	7	15/52/33 2000	U	Exp.	1.06
5/20				Pre.	1.1
6/3	8		L	Exp.	1.23
3/26				Pre.	0.85
4/9	7	N3000	U	Exp.	0.93
3/24				Pre.	1.1
4/7	8		L	Exp.	1.18

TABLE AII. 67

RESTING ORAL TEMPERATURE, °F

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/8	——	——	——	98.0	——	1/23	98.5	98.2	98.2	98.5
1/9	——	99.0	98.1	——	——	1/29	98.5	97.9	——	——

TABLE AII. 67 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/10	97.4	——	——	——	——	1/30	——	——	98.0	——
1/15	——	——	——	98.4	——	1/31	——	——	——	98.4
1/16	97.2	97.4	97.7	——	——	2/6	98.5	97.9	97.9	98.4
1/22	97.4	97.4	——	98.1	——	2/9	——	——	——	98.1
1/23	——	——	98.5	——	——	2/10	——	97.6	——	——
1/26	——	——	98.4	——	——	2/11	——	——	97.9	——
1/29	——	98.1	——	——	——	2/13	98.6	98.1	97.8	98.0
1/30	97.8	——	——	98.1	——	2/20	98.2	98.5	98.8	98.2
2/5	97.5	98.1	98.4	98.1	97.7	2/27	97.9	97.9	97.8	98.1
2/12	97.8	98.1	98.1	——	97.8	3/6	98.0	97.4	97.9	97.9
2/19	98.0	97.9	98.0	——	97.7	3/9	——	——	97.4	——
2/24	——	——	97.4	——	97.1	3/13	98.2	97.1	98.6	98.0
2/26	97.8	97.8	——	——	——	3/20	98.2	97.4	98.3	98.6
3/5	98.1	97.7	97.8	——	97.2	3/27	98.1	98.0	98.4	98.1
3/12	98.2	97.7	97.7	——	97.3	4/3	98.0	97.9	97.4	98.2
3/19	98.1	97.5	97.9	——	97.3	4/10	98.1	98.9	97.6	98.4
3/25	98.3	97.2	97.6	——	97.4	4/17	98.2	97.6	97.7	98.2
4/2	97.9	98.2	——	——	96.3	4/24	98.0	97.6	97.9	98.1
4/8	——	——	——	——	97.8	5/1	98.1	97.3	98.0	97.9
4/9	97.8	98.0	97.9	——	——	5/6	98.1	97.1	——	——
4/16	97.8	97.4	97.7	——	97.5	5/8	——	——	97.7	98.0
4/21	——	——	——	——	97.9	5/15	98.4	97.3	98.0	98.0
4/23	98.1	97.5	97.7	——	——	5/22	98.2	97.2	98.1	98.4
4/30	98.0	98.0	97.9	——	97.4	5/29	98.1	97.7	97.7	98.3
5/5	——	98.0	97.7	——	——	6/4	——	——	97.8	——
5/7	98.3	——	——	——	97.4	6/5	98.4	97.2	——	98.2
5/14	97.7	97.6	98.2	——	97.1	6/12	98.4	97.4	——	99.0
5/21	98.0	97.3	98.0	——	96.7					
5/28	98.0	97.9	98.2	——	97.4					

TABLE AII. 68

RESTING BLOOD PRESSURE, mm Hg

Date	Subject No.					Date	Subject No.				
1953	1	2	3	4	12	1953	5	6	7	8	
1/8	--	--	--	112/76	--	1/23	114/68	120/65	114/64	102/65	
1/9	114/68	124/85	142/86	--	--	1/29	--	126/68	--	--	
1/15	--	--	--	110/72	--	1/30	117/70	--	108/54	--	
1/16	125/78	115/64	130/76	--	--	1/31	--	--	--	108/78	
1/22	126/74	112/62	--	108/77	--	2/6	120/68	115/74	115/65	113/68	
1/23	--	--	123/76	--	--	2/9	--	--	--	104/65	
1/27	--	--	122/76	--	--	2/10	--	107/75	--	--	
1/29	--	120/78	--	--	--	2/11	--	--	95/65	--	
1/30	118/73	--	--	108/75	--	2/13	115/75	119/82	96/70	105/54	
2/5	115/68	115/74	133/79	104/69	108/65	2/20	118/65	125/65	102/48	106/60	
2/12	113/68	110/76	130/82	--	108/62	2/27	112/69	116/66	103/67	105/56	
2/19	120/78	114/80	126/82	--	106/70	3/6	105/75	100/74	102/70	105/65	
2/24	--	--	125/84	--	104/72	3/9	--	--	104/66	--	
2/26	100/70	101/65	--	--	--	3/13	105/72	115/69	108/68	99/62	
3/5	112/70	105/75	126/64	--	107/58	3/20	120/68	124/76	104/56	112/65	
3/12	116/72	97/68	126/64	--	102/66	3/27	118/78	121/72	106/55	108/74	
3/19	126/79	114/80	126/84	--	103/63	4/3	109/70	110/68	98/66	108/66	
3/26	118/76	107/78	126/77	--	105/83	4/10	115/75	108/74	104/60	115/70	
4/2	115/68	105/66	--	--	106/58	4/17	116/78	116/76	102/72	109/65	
4/8	--	--	--	--	111/62	4/24	118/70	120/70	107/68	106/65	
4/9	122/80	110/76	122/84	--	--	5/1	106/72	108/78	105/68	102/66	
4/16	110/78	105/78	120/90	--	106/68	5/6	104/68	116/70	--	--	
4/21	--	--	--	--	98/59	5/8	--	--	98/66	99/66	
4/23	103/70	103/72	134/82	--	--	5/15	118/68	120/82	108/54	106/62	
4/30	122/70	102/55	138/70	--	99/60	5/22	116/77	126/68	105/50	103/65	
5/5	--	116/82	124/88	--	--	5/29	114/72	128/75	103/74	98/53	
5/6	--	--	--	--	105/65	6/4	--	--	102/60	--	
5/7	129/78	--	--	--	--	6/5	112/60	125/75	--	109/63	
5/14	112/78	120/83	126/83	--	102/70	6/12	112/68	123/83	--	119/60	
5/21	111/75	108/80	125/90	--	108/65						
5/28	106/72	110/76	120/80	--	108/66						

107

TABLE AII. 69

EXERCISE-STRESS: BLOOD PRESSURE (mm Hg)

Date 1953	Subject No.	Nutrient Mixture	Water Intake	Period	Systolic Pressure Rest	5'	10'	Diastolic Pressure Rest	5'	10'	Pulse Pressure Rest	5'	10'
2/12				Pre	119	144	122	80	65	88			
2/24	3	STO	U	Exp	125	143	134	80	75	86	45	68	48
2/11				Pre	120	135	124	64	65	75			
2/24	12		L	Exp	101	130	123	72	70	74	29	60	49
1/30				Pre	126	125	110	63	60	58			
2/11	7		U	Exp	103	123	110	68	40	63	35	83	47
1/29				Pre	108	132	120	60	50	70			
2/9	8		L	Exp	115	126	114	65	67	72	50	59	42
2/27				Pre	125	145	123	73	66	68			
3/13	5	0/100/0	L	Exp	114	140	124	72	65	76	42	75	48
2/25		1000		Pre	123	134	125	74	72	76			
3/11	6		U	Exp	110	132	118	66	7[illegible]	66	44	56	52
2/27				Pre	125	145	128	72	6[illegible]	68			
5/6	5	15/52/33	L	Exp	112	130	116	80	0	68	32	130	48
2/26		1000		Pre	123	134	125	74	72	76			
5/6	6		U	Exp	120	145	128	75	58	66	45	87	62
4/7				Pre	130	140	120	85	80	80			
3/23	1	30/0/70	L	Exp	118	134	129	76	62	75	42	72	54
4/9		2000		Pre	115	115	115	75	70	76			
3/26	2		U	Exp	106	122	122	84	85	68	22	37	36
5/5				Pre	120	136	122	70	64	72			
5/20	1	0/100/0	L	Exp	117	128	112	66	74	78	44	52	34
5/7		2000		Pre	125	125	116	82	83	83			
5/21	2		U	Exp	100	136	112	78	66/10	72	22	70	40
4/8				Pre	130	140	132	88	60	94			
4/22	3	2/20/78	U	Exp	122	140	126	70	64	86	52	76	40
4/7		2000		Pre	130	135	115	64	45	85			
4/21	12		L	Exp	110	126	116	68	20	70	42	106	46
5/20	7			Pre	112	110	106	65/0	50	74			
6/4		15/52/33	U	Exp	10[illegible]	115	110	66	48/0	66	42	67	46
5/20		2000		Pre	110	122	114	66	74/20	60/44			
6/3	8		L	Exp	110	130	110	64	69	65	46	61	45
3/26				Pre	106	124	118	57	70	80			
4/9	7	N3000	U	Exp	107	104	112	50	64	60	57	40	52
3/24				Pre	120	146	114	78	66/0	76/48			
4/7	8		L	Exp	114	137	112	59	68/0	65	55	69	46

108

STAT

TABLE AII..68

RESTING BLOOD PRESSURE, mm Hg

Date	Subject No. 1	2	3	4	22	Date	Subject No. 5	6	7	8
1953						1953				
1/8	--	--	--	112/76	--	1/23	114/68	123/65	114/64	102/65
1/9	--	--	142/86	--	--	1/29	--	125/68	--	--
1/15	114/68	124/85	--	110/72	--	1/30	117/70	--	108/64	103/78
1/16	--	115/64	130/76	--	--	1/31	--	--	--	113/68
1/22	125/78	112/62	--	108/77	--	2/6	120/68	115/74	115/65	104/65
1/23	126/74	--	123/76	--	--	2/9	--	--	--	--
1/27	--	--	122/76	--	--	2/10	--	107/75	--	--
1/29	--	120/78	--	108/75	--	2/11	--	--	95/65	105/64
1/30	118/73	--	133/79	104/69	--	2/13	115/75	117/82	96/70	106/60
2/5	115/68	115/74	130/82	--	--	2/20	118/65	125/65	100/48	105/56
2/12	113/68	110/76	126/82	--	--	2/27	112/69	116/68	103/67	105/65
2/19	120/78	111/80	125/84	--	--	3/6	105/75	100/74	109/70	--
2/24	--	--	--	--	--	3/9	--	--	104/66	99/62
2/26	100/70	101/65	126/84	--	--	3/13	105/72	115/69	104/56	112/65
3/5	112/70	105/75	126/84	--	--	3/20	120/68	124/76	103/68	103/74
3/12	116/72	111/80	126/81	--	--	3/27	118/78	124/72	105/55	108/55
3/19	126/79	107/78	126/77	--	--	4/3	109/70	110/68	98/66	103/66
3/26	118/76	105/66	--	--	--	4/10	115/75	106/76	104/60	115/70
4/2	115/68	--	--	--	--	4/17	116/78	116/70	102/72	109/65
4/8	--	--	--	--	--	4/21	118/70	120/70	107/68	106/55
4/9	--	--	--	--	--	5/1	106/72	108/78	105/68	102/68
4/16	--	--	--	--	--	5/6	104/68	116/70.	--	--
4/21	--	--	--	--	--	5/8	--	--	98/66	99/66
4/23	--	--	--	--	--	5/15	118/68	120/82	108/54	106/62
4/30	--	--	--	--	--	5/22	116/77	126/68	105/50	103/65
5/5	--	--	--	--	--	5/29	111/72	128/75	103/74	98/63
5/7	--	--	--	--	--	6/4	--	--	102/60	--
5/11	129/78	120/83	126/83	--	--	6/5	112/60	125/75	--	109/63
5/21	111/75	108/80	125/80	--	--	6/12	112/68	123/63	--	119/60
5/28	106/72	110/76	120/80	--	--					
						6/19	--	--	--	--
						6/26	--	--	--	--
						7/3	--	--	--	--
						7/10	--	--	--	--
						7/17	--	--	--	--
						7/24	--	--	--	--
						7/31	--	--	--	--
						8/7	--	--	--	--
						8/14	--	--	--	--
						8/21	--	--	--	--
						8/28	--	--	--	--

TABLE AII..70

RESTING PULSE RATE, beats/min

Date	Subject No. 1	2	3	4	12	Date	Subject No. 5	6	7	8
1953						1953				
1/8	--	--	--	72	--	1/23	74	66	76	84
1/9	--	90	72	--	--	1/30	80	64	74	--
1/10	60	--	--	--	--	1/31	--	--	--	86
1/15	--	--	--	70	--	2/6	60	58	56	78
1/16	48	64	70	--	--	2/9	--	--	--	64
1/22	48	74	--	--	78	2/10	--	50	60	--
1/23	--	--	74	--	--	2/13	64	58	70	80
1/27	--	--	62	--	--	2/20	84	76	72	92
1/29	--	64	--	--	--	2/27	72	78	74	84
1/30	48	--	--	74	--	3/6	56	60	58	76
2/5	56	66	72	70	70	3/9	--	--	50	--
2/12	58	58	64	--	72	3/13	56	48	56	74
2/19	42	64	56	--	68	3/20	68	66	68	82
2/24	--	--	54	--	60	3/27	70	66	70	86
2/26	48	54	--	--	--	4/3	64	56	68	76
3/5	58	58	64	--	74	4/10	60	42	60	78
3/12	68	64	76	--	74	4/17	68	66	66	88
3/19	56	76	74	--	70	4/24	80	80	72	88
3/26	58	64	58	--	64	5/1	68	60	64	74
4/2	60	68	--	--	60	5/6	60	54	--	--
4/8	--	--	--	--	72	5/8	--	--	56	74
4/9	60	82	82	--	--	5/15	78	70	64	78
4/16	47	60	74	--	70	5/22	76	76	78	84
4/21	--	--	--	--	68	5/29	68	78	72	80
4/23	48	64	84	--	--	6/4	--	--	62	--
4/30	64	60	86	--	64	6/5	68	56	--	70
5/5	--	68	70	--	--	6/12	76	70	--	94
5/7	62	--	--	--	64					
5/14	50	70	76	--	56					
5/21	52	58	76	--	50					
5/28	56	58	66	--	60					

STAT

TABLE AII. 71

DAILY URINE VOLUME; ml/24 hr

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/6	1630	1260	570	1350	--	--	--	--	--
1/7	800	1100	830	1080	--	--	--	--	--
1/8	1375	1750	1060	1350	--	--	--	--	--
1/9	1100	2035	1255	1980	--	--	--	--	--
1/10	1610	1140	1295	1585	--	--	--	--	--
1/11	1785	1050	1135	1385	--	--	--	--	--
1/12	1750	1125	950	1240	--	--	--	--	--
1/13	1220	1140	1130	1380	--	--	--	--	--
1/14	1540	1835	1020	1120	--	--	--	--	--
1/15	1195	1140	1205	1120	--	--	--	--	--
1/16	1595	1560	1260	1385	--	--	--	--	--
1/17	1255	1220	1040	1180	--	--	--	--	--
1/18	2365	1990	2320	2240	--	--	--	--	--
1/19	1315	1260	830	1000	--	--	--	--	--
1/20	1090	1140	720	985	--	1270	1155	2535	1140
1/21	705	1060	390	1000	--	1680	1250	1880	1640
1/22	565	1260	620	905	--	1400	1390	2190	1620
1/23	940	1265	725	990	--	1570	1200	2140	1210
1/24	955	1880	740	615	--	1200	1190	1800	1220
1/25	880	1250	540	615	--	1000	1130	1680	1220
1/26	940	1635	660	520	--	1660	1380	2015	1250
1/27	825	1155	830	680	--	1225	1385	1730	1595
1/28	790	1190	800	880	--	1740	2150	2180	1650
1/29	630	1580	1000	550	--	1280	1810	1540	1150
1/30	675	2020	1325	710	--	1410	1970	1840	1300
1/31	740	930	1170	690	--	1060	1130	2020	1145
2/1	1325	1630	2230	1880	--	2170	2130	1925	2230
2/2	2150	1660	1110	1320	930	1140	770	2520	830
2/3	2800	1630	1110	1670	1780	665	900	1190	580
2/4	1700	--	400	1615	2350	--	830	1095	645
2/5	2960	1375	690	1805	2320	990	805	1060	530
2/6	1940	965	870	1170	1645	800	620	1260	420
2/7	2400	675	875	1150	1500	810	595	1200	465
2/8	1830	740	935	1520	1225	1040	490	1090	510
2/9	3140	1220	870	--	1670	1010	530	1570	475
2/10	1680	1405	1050	--	1440	1110	680	2040	1280
2/11	1780	1435	1005	--	1980	1560	910	1300	1500
2/12	1680	1800	2200	--	1470	1760	700	1970	1360
2/13	2330	--	1480	--	1560	--	1620	1100	1710
2/14	1630	1350	1690	--	1545	1325	1700	2420	2800
2/15	3060	2195	1530	--	2290	2280	2580	3325	3450
2/16	1560	850	1345	--	1030	1695	1690	2850	2180

TABLE AII. 71 (contd)

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
2/17	1055	760	850	850	1400	1400	2670	2330
2/18	1770	900	590	740	870	1440	2850	2390
2/19	955	800	660	770	1140	1070	2920	2210
2/20	1065	650	735	710	1745	1600	2420	2100
2/21	600	495	390	500	1620	1690	2650	2350
2/22	1005	570	155	600	1420	1505	2295	1690
2/23	885	455	165	525	1080	1140	2200	1320
2/24	640	490	290	395	1180	1330	2980	1950
2/25	990	440	830	900	1940	1470	3060	--
2/26	675	450	590	740	1810	985	2900	1565
2/27	820	490	570	1320	1800	1150	2930	2040
2/28	1050	650	1000	2170	1610	1330	2720	1600
3/1	3000	760	2200	3500	2260	1700	2820	2780
3/2	2100	805	1540	1960	1090	1150	1050	1800
3/3	1930	1580	1110	1690	485	1070	980	1120
3/4	3660	2810	700	1550	430	--	890	1320
3/5	2330	1105	770	1580	450	255	810	2400
3/6	3200	1870	1345	1600	275	270	715	1680
3/7	2320	1830	1040	1900	220	550	730	1720
3/8	2230	1650	885	1560	240	560	725	1770
3/9	2710	1125	816	1710	230	280	730	1765
3/10	2080	1390	960	1520	230	490	655	1330
3/11	2835	1370	995	1725	240	345	710	2100
3/12	1760	1140	1175	1140	270	330	930	2050
3/13	2300	1620	765	2010	270	525	855	1120
3/14	1900	1180	745	1270	945	610	785	1820
3/15	3680	2670	2140	2740	1090	1100	760	2420
3/16	1015	1270	940	1075	1850	1850	1530	1100
3/17	1180	1280	650	1245	1770	1165	2135	1760
3/18	1000	1110	555	810	1960	1945	3380	1595
3/19	975	1295	735	1350	2230	1730	3765	2210
3/20	680	1140	800	1045	1980	1560	4670	2240
3/21	645	1100	515	945	1530	1220	3125	2475
3/22	680	1270	630	1080	1470	1680	2680	1610
3/23	595	1200	870	1000	2035	2090	3190	2410
3/24	680	1235	640	1010	1720	1270	3150	2310
3/25	725	1165	725	1185	1865	1390	3615	2270
3/26	790	1345	695	1330	1660	1250	3725	2230
3/27	580	1630	1080	1090	1220	1365	1375	2025
3/28	855	930	670	960	1130	1390	2100	1890
3/29	640	1195	900	2080	2140	2450	3680	2940
3/30	1620	925	715	1485	1140	1140	3225	1230
3/31	2245	1695	590	1300	515	395	2410	1015
4/1	2710	1110	--	1250	930	515	2275	1005
4/2	2355	1585	--	2395	1005	620	2400	985

STAT

TABLE AII. 71 (contd)

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
4/3	2880	810	--	1380	710	720	2680	975
4/4	1195	1440	--	1755	695	445	2350	875
4/5	2210	1660	2480	1490	580	450	2330	1085
4/6	3260	1620	1045	1335	340	390	2040	920
4/7	2005	1170	1060	1735	265	285	2080	865
4/8	3265	1280	1035	1115	330	310	2500	835
4/9	1930	1005	1200	1990	615	290	2120	920
4/10	2730	1125	1225	1355	455	315	2520	835
4/11	1790	1335	1105	1240	625	480	2060	870
4/12	4160	3960	1985	1550	765	400	2790	1540
4/13	1740	1395	895	745	1860	1495	2700	1565
4/14	1220	910	520	920	2210	1845	2410	2770
4/15	1270	510	405	490	1790	--	--	1835
4/16	1400	510	430	585	1900	1630	3330	2090
4/17	1085	545	405	500	1615	2040	2750	2230
4/18	775	460	380	500	1790	1960	3190	2240
4/19	1125	515	400	430	1900	1550	2900	2335
4/20	1325	380	605	430	1315	1280	3115	1950
4/21	1890	465	680	670	1355	1470	2010	1935
4/22	1665	380	330	1140	1460	1680	2000	1225
4/23	1910	395	380	795	1605	1580	1665	1575
4/24	1010	355	435	1890	1525	1700	2360	2470
4/25	1295	620	525	2300	1800	1330	2180	1420
4/26	1420	325	1315	3260	2940	2560	4050	3310
4/27	1195	840	1405	2330	1700	1985	1160	1800
4/28	2355	955	1320	1250	585	995	700	1300
4/29	2480	1015	1175	1205	505	845	450	1200
4/30	2200	1530	775	1065	480	515	380	1315
5/1	1505	1605	850	1220	435	460	345	1110
5/2	2250	1550	990	1505	385	530	340	1090
5/3	1545	1185	1105	1460	390	430	370	1180
5/4	2070	1045	870	1240	430	635	335	840
5/5	2800	1465	1185	1760	410	625	310	830
5/6	1760	2350	1330	1595	480	705	305	780
5/7	2515	1445	1330	1780	980	1130	290	905
5/8	2405	990	1050	1375	1515	1555	310	1260
5/9	1900	1085	935	1550	1440	1405	420	820
5/10	3090	1835	1630	1230	2160	2290	630	1265
5/11	1830	450	490	1600	1630	1095	720	575
5/12	480	525	365	800	1315	1720	950	1090
5/13	380	805	405	575	1560	1375	1215	2350
5/14	515	1220	400	1185	1295	1330	2520	2555
5/15	270	800	160	345	1585	1380	1945	2120
5/16	370	1120	350	790	1500	1600	3115	2220

TABLE AII. 71 (contd)

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
5/17	320	1740	390	1110	1370	1405	2295	1570
5/18	310	1070	370	395	1400	1260	2230	1395
5/19	270	3220	240	435	1080	1475	1235	1295
5/20	430	435	225	955	1130	1205	2235	2270
5/21	330	2415	300	565	1220	1050	2460	1360
5/22	265	1125	215	515	1590	1050	1535	1985
5/23	265	1190	215	635	1740	1175	685	1390
5/24	835	1250	960	2470	1905	2185	1835	2020
5/25	515	855	930	580	1080	1020	1305	535
5/26	1305	1220	1210	1590	1000	810	1215	475
5/27	1530	1435	1630	2350	1475	920	1570	565
5/28	1685	1035	1230	1930	1250	860	1620	550
5/29	2810	955	1215	1955	790	925	1475	490
5/30	1310	915	895	1460	920	650	3170	585
5/31	1050	810	1195	1320	1010	1275	1610	2310
6/1	--	--	--	--	1480	960	1650	1260
6/2	--	--	--	--	1390	2150	1960	1475
6/3	--	--	--	--	1005	1950	1900	1110
6/4	--	--	--	--	1205	2250	1830	1080
6/5	--	--	--	--	755	1380	1285	1020
6/6	--	--	--	--	1310	1840	845	1445
6/7	--	--	--	--	2140	2570	1330	1900
6/8	--	--	--	--	1460	890	--	1070
6/9	1240	970	--	--	1300	1350	--	1460
6/10	--	--	985	790	1040	740	--	1385
6/11	--	--	--	--	880	870	--	1410
6/12	--	--	--	--	1045	915	--	1210

TABLE AII. 72

SPECIFIC GRAVITY OF URINE (Corrected to 15.6° C)

Date	Subject No.							
1953	1	2	3	4	12	5	6	7	8
1/6	1.020	1.022	1.025	1.024	--	--	--	--	--
1/7	1.028	1.023	1.031	1.028	--	--	--	--	--
1/8	1.023	1.015	1.027	1.029	--	--	--	--	--
1/9	1.024	1.014	1.021	1.024	--	--	--	--	--
1/10	1.021	1.018	1.021	1.027	--	--	--	--	--
1/11	1.015	1.023	1.028	1.025	--	--	--	--	--

STAT

TABLE AII. 72 (contd)

Date	Subject No.								
1953	1	2	3	4	12	5	6	7	8
1/12	1.014	1.020	1.029	1.025	--	--	--	--	--
1/13	1.027	1.024	1.030	1.027	--	--	--	--	--
1/14	1.021	1.016	1.027	1.025	--	--	--	--	--
1/15	1.023	1.019	1.026	1.023	--	--	--	--	--
1/16	1.021	1.018	1.027	1.025	--	--	--	--	--
1/17	1.021	1.020	1.029	1.032	--	--	--	--	--
1/18	1.014	1.010	1.018	1.015	--	--	--	--	--
1/19	1.024	1.023	1.032	1.027	--	--	--	--	--
1/20	1.029	1.024	1.032	1.030	--	1.028	1.028	1.023	1.025
1/21	1.030	1.025	1.038	1.024	--	1.022	1.023	1.014	1.023
1/22	1.029	1.021	1.030	1.028	--	1.027	1.027	1.020	1.020
1/23	1.028	1.024	1.030	1.029	--	1.024	1.030	1.017	1.027
1/24	1.032	1.014	1.027	1.029	--	1.020	1.027	1.020	1.026
1/25	1.029	1.015	1.026	1.031	--	1.024	1.029	1.014	1.026
1/26	1.030	1.022	1.027	1.030	--	1.019	1.023	1.016	1.023
1/27	1.028	1.021	1.029	1.028	--	1.022	1.027	1.019	1.020
1/28	1.025	1.020	1.022	1.025	--	1.023	1.017	1.019	1.017
1/29	1.028	1.023	1.023	1.030	--	1.024	1.017	1.023	1.013
1/30	1.021	1.014	1.022	1.019	--	1.022	1.028	1.020	1.025
1/31	1.022	1.024	1.022	1.027	--	1.024	1.025	1.008	1.028
2/1	1.020	1.019	1.003	1.007	1.022	1.016	1.009	1.012	1.015
2/2	1.012	1.025	1.019	1.018	1.013	1.019	1.033	1.004	1.024
2/3	1.009	1.010	1.019	1.024	1.013	1.026	1.014	1.016	1.028
2/4	1.012	--	1.027	1.020	1.013	--	1.020	1.022	1.023
2/5	1.013	1.022	1.025	1.024	1.021	1.021	1.022	1.022	1.029
2/6	1.010	1.025	1.026	1.020	1.019	1.020	1.029	1.015	1.032
2/7	1.009	1.028	1.019	1.016	1.026	1.018	1.020	1.014	1.032
2/8	1.019	1.024	1.029	1.024	--	1.019	1.024	1.018	1.026
2/9	1.010	1.027	1.024	--	1.020	1.019	1.019	1.012	1.031
2/10	1.015	1.023	1.021	--	1.023	1.019	1.026	1.010	1.010
2/11	1.013	1.019	1.030	--	1.018	1.017	1.016	1.009	1.018
2/12	1.008	1.017	1.013	--	1.022	1.018	1.022	1.004	1.022
2/13	1.008	--	1.019	--	1.021	--	1.014	1.015	1.020
2/14	1.014	1.019	1.024	--	1.022	1.021	1.015	1.016	1.013
2/15	1.005	1.007	1.013	--	1.009	1.009	1.010	1.010	1.004
2/16	1.008	1.029	1.015	--	1.018	1.010	1.018	1.013	1.019
2/17	1.017	1.020	1.015	--	1.017	1.017	1.021	1.014	1.015
2/18	1.011	1.018	1.021	--	1.020	1.019	1.023	1.013	1.015
2/19	1.015	1.018	1.014	--	1.023	1.019	1.028	1.013	1.016
2/20	1.011	1.022	1.015	--	1.026	--	1.027	1.020	1.020
2/21	1.015	1.022	1.016	--	1.027	1.022	1.020	1.015	1.018
2/22	1.006	1.023	1.029	--	1.024	1.020	1.023	1.018	1.020
2/23	1.009	1.024	1.025	--	1.024	1.027	1.027	1.016	1.029
2/24	1.011	1.027	1.029	--	1.023	1.021	1.020	1.020	1.021

TABLE AII. 72 (contd)

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
2/25	1.004	1.024	1.015	1.010	1.021	1.027	1.008	1.022
2/26	1.026	1.019	1.024	1.023	1.014	1.027	1.015	1.021
2/27	1.015	1.020	1.026	1.017	1.013	1.024	1.010	1.016
2/28	1.017	1.024	1.023	1.014	1.014	1.024	1.014	1.018
3/1	1.006	1.010	1.011	1.009	1.013	1.016	1.013	1.009
3/2	1.008	1.008	1.014	1.021	1.014	1.016	1.020	1.020
3/3	1.017	1.015	1.022	1.024	1.022	1.010	1.027	1.019
3/4	1.003	1.012	1.023	1.017	1.019	--	1.023	1.018
3/5	1.010	1.012	1.022	1.018	1.016	1.028	1.026	1.006
3/6	1.011	1.018	1.021	1.026	1.032	1.032	1.030	1.013
3/7	1.014	1.019	1.020	1.018	1.031	1.016	1.031	1.015
3/8	1.015	1.020	1.027	1.026	1.033	1.016	1.031	1.016
3/9	1.011	1.021	1.024	1.024	1.029	1.024	1.022	1.012
3/10	1.019	1.024	1.023	1.026	1.032	1.013	1.026	1.015
3/11	1.010	1.018	1.025	1.021	1.031	1.023	1.030	1.008
3/12	1.011	1.019	1.021	1.023	1.025	1.022	1.035	1.008
3/13	1.009	1.018	1.023	1.020	1.026	1.023	1.027	1.011
3/14	1.018	1.019	1.027	1.024	1.010	1.018	1.026	1.015
3/15	1.006	1.015	1.005	1.007	1.023	1.023	1.023	1.013
3/16	1.023	1.022	1.024	1.027	1.019	1.019	1.020	1.028
3/17	1.025	1.020	1.025	1.019	1.018	1.020	1.013	1.019
3/18	1.030	1.020	1.027	1.026	1.019	1.018	1.007	1.023
3/19	1.029	1.021	1.027	1.020	1.015	1.022	1.009	1.020
3/20	1.028	1.019	1.028	1.023	1.016	1.019	1.009	1.016
3/21	1.022	1.019	1.033	1.023	1.017	1.024	1.013	1.008
3/22	1.022	1.023	1.026	1.022	1.024	1.021	1.010	1.020
3/23	1.024	1.019	1.023	1.029	1.020	1.019	1.015	1.022
3/24	1.023	1.024	1.029	1.022	1.017	1.026	1.015	1.015
3/25	1.021	1.024	1.030	1.023	1.010	1.027	1.008	1.015
3/26	1.023	1.023	1.031	1.018	1.019	1.007	1.003	1.015
3/27	1.028	1.027	1.029	1.024	1.027	1.024	1.006	1.021
3/28	1.025	1.025	1.031	1.030	1.026	1.027	1.018	1.021
3/29	1.029	1.022	1.019	1.008	1.015	1.016	1.006	1.010
3/30	1.017	1.027	1.025	1.019	1.010	1.018	1.013	1.029
3/31	1.020	1.021	1.023	1.022	1.025	1.029	1.013	1.034
4/1	1.013	1.023	--	1.022	1.011	1.027	1.011	1.013
4/2	1.010	1.010	--	1.009	1.009	1.030	1.012	1.028
4/3	1.010	1.023	--	1.024	1.009	1.017	1.011	1.036
4/4	1.013	1.018	--	1.022	1.013	1.026	1.008	1.034
4/5	1.010	1.020	1.033	1.024	1.015	1.025	1.013	1.033
4/6	1.014	1.019	1.017	1.025	1.026	1.032	1.014	1.034
4/7	1.013	1.020	1.025	1.023	1.030	1.033	1.013	1.034
4/8	1.007	1.019	1.026	1.028	1.026	1.034	1.011	1.035
4/9	1.013	1.025	1.024	1.015	1.011	1.036	1.012	1.033

STAT
STAT

TABLE AII. 72 (contd)

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
4/10	1.008	1.020	1.025	1.022	1.022	--	1.012	1.035
4/11	1.019	1.021	1.024	1.027	1.028	1.010	1.014	1.031
4/12	1.005	1.009	1.007	1.010	1.012	1.025	1.010	1.016
4/13	1.008	1.011	1.018	1.022	1.017	1.018	1.012	1.022
4/14	1.013	1.014	1.022	1.020	1.012	1.018	1.012	1.011
4/15	1.007	1.026	1.025	1.031	1.017	--	--	1.014
4/16	1.011	1.031	1.024	1.030	1.020	1.023	1.015	1.017
4/17	1.008	1.025	1.021	1.029	1.016	1.022	1.016	1.015
4/18	1.014	1.026	1.022	1.030	1.021	1.026	1.016	1.015
4/19	1.008	1.028	1.025	1.029	1.020	1.023	1.017	1.013
4/20	1.005	1.032	1.013	1.032	1.020	1.016	1.009	1.009
4/21	1.009	1.030	1.023	1.030	1.021	1.024	1.022	1.018
4/22	1.007	1.028	1.027	1.009	1.020	1.024	1.017	1.017
4/23	1.008	1.030	1.025	1.020	1.016	1.025	1.020	1.016
4/24	1.009	1.032	1.024	1.021	1.019	1.028	1.015	1.013
4/25	1.014	1.035	1.015	1.012	1.017	1.025	1.020	1.016
4/26	1.005	1.013	1.009	1.008	1.013	1.013	1.017	1.009
4/27	1.019	1.023	1.008	1.013	1.011	1.013	1.016	1.008
4/28	1.013	1.029	1.018	1.022	1.028	1.019	1.020	1.006
4/29	1.009	1.028	1.028	1.023	1.030	1.023	1.031	1.012
4/30	1.018	1.017	1.031	1.028	1.029	1.030	1.033	1.009
5/1	1.013	1.018	1.028	1.021	1.031	1.028	1.033	1.008
5/2	1.018	1.018	1.028	1.019	1.030	1.027	1.030	1.008
5/3	1.018	1.023	1.021	1.019	1.028	1.032	1.032	1.006
5/4	1.013	1.023	1.029	1.030	1.025	1.022	1.031	1.008
5/5	1.013	1.018	1.006	1.018	1.024	1.022	1.031	1.008
5/6	1.022	1.016	--	1.022	1.027	1.017	1.032	1.009
5/7	1.019	1.013	1.020	1.019	1.018	1.013	1.031	1.019
5/8	1.013	1.023	1.027	1.024	1.020	1.026	1.033	1.006
5/9	1.018	1.029	1.015	1.023	1.022	1.023	1.038	1.013
5/10	1.007	1.019	1.013	1.008	1.020	1.013	1.014	1.004
5/11	1.013	1.028	1.030	1.012	1.015	1.030	1.025	1.019
5/12	1.018	1.018	1.030	1.012	1.022	1.020	1.010	1.020
5/13	1.028	1.013	1.030	1.019	1.026	1.028	1.021	1.016
5/14	1.019	1.008	1.026	1.009	1.023	1.031	1.018	1.016
5/15	1.028	1.021	1.030	1.024	1.023	1.032	1.026	1.019
5/16	1.020	1.007	1.009	1.007	1.029	1.029	1.017	1.018
5/17	1.029	1.008	1.028	1.008	1.029	1.030	1.022	1.021
5/18	1.028	1.009	1.024	1.018	1.023	1.028	1.018	1.023
5/19	1.030	1.001	1.034	1.013	1.026	1.023	1.024	1.027
5/20	1.031	1.014	1.034	1.008	1.026	1.023	1.018	1.013
5/21	1.029	1.002	1.031	1.013	1.023	--	1.017	1.023
5/22	1.003	1.031	1.014	1.018	1.018	1.023	1.018	1.017
5/23	1.030	1.008	1.038	1.020	1.023	1.028	1.020	1.023
5/24	1.008	1.018	1.011	1.004	1.013	1.017	1.027	1.021

TABLE AII. 72 (contd)

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
5/25	1.025	1.024	1.024	1.029	1.031	1.031	1.024	1.032
5/26	1.026	1.024	1.022	1.023	1.028	1.034	1.020	1.035
5/27	1.024	1.024	1.019	1.022	1.019	1.023	1.014	1.031
5/28	1.022	1.026	1.028	1.019	1.023	1.033	1.015	1.037
5/29	1.015	1.030	1.031	1.024	1.030	1.037	1.019	1.039
5/30	1.023	1.033	1.027	1.027	1.028	1.034	1.012	1.034
5/31	1.028	1.031	1.015	1.026	1.031	1.029	1.017	1.010
6/1	--	--	--	--	1.028	1.026	1.016	1.017
6/2	--	--	--	--	1.024	1.019	1.014	1.017
6/3	--	--	--	--	1.024	1.019	1.015	1.017
6/4	--	--	--	--	1.021	1.024	1.011	1.015
6/5	--	--	--	--	1.039	1.019	1.019	1.018
6/6	--	--	--	--	1.024	1.014	1.020	1.014
6/7	--	--	--	--	1.011	1.012	1.010	1.012
6/8	--	--	--	--	1.026	1.029	--	1.019
6/9	--	--	--	--	1.025	1.023	--	1.017
6/10	--	--	--	--	1.030	1.029	--	1.017
6/11	--	--	--	--	1.031	1.035	--	1.025
6/12	--	--	--	--	1.027	1.021	--	1.019

TABLE AII. 73

URINE OSMOLARITY, Osm/l

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
4/27	1.30	1.13	0.71	0.95	0.69	0.74	0.94	0.32
4/28	0.73	1.12	0.65	1.08	2.50	0.75	0.78	0.28
4/29	0.61	0.85	1.05	0.88	1.14	1.00	1.37	0.31
4/30	0.73	0.98	1.07	0.98	1.25	--	1.16	0.19
5/1	0.83	0.83	1.09	1.20	0.84	1.18	1.08	0.20
5/2	0.82	0.93	1.22	1.12	1.36	1.12	1.11	0.33
5/3	0.97	1.09	1.24	1.05	1.19	1.02	0.58	0.23
5/4	0.73	1.11	--	1.70	1.22	0.62	0.97	0.24
5/5	--	0.89	1.38	1.14	1.19	0.78	1.04	0.14
5/6	0.81	0.60	0.99	1.23	0.97	0.66	1.09	0.08
5/7	0.77	0.81	--	1.38	0.77	0.53	0.66	0.01
5/8	0.64	1.04	1.25	0.98	0.99	1.11	0.64	0.07
5/9	1.00	1.21	0.75	1.32	1.32	1.25	1.07	0.42
5/10	--	--	--	--	--	--	--	--
5/11	0.51	1.13	1.25	0.43	0.96	1.16	1.02	0.52

STAT
STAT

TABLE AII. 73 (contd)

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
5/12	--	--	--	--	0.95	1.09	1.09	0.54
5/13	0.74	0.28	0.75	0.42	1.22	1.05	0.81	0.52
5/14	0.54	0.16	0.85	0.20	0.92	1.20	0.59	0.53
5/15	0.50	0.07	0.06	0.52	1.01	1.41	1.33	0.71
5/16	0.51	--	0.73	0.19	1.05	1.02	0.80	0.72
5/17	0.25	0.03	0.25	1.24	0.97	1.02	0.79	1.04
5/18	0.06	0.15	0.83	0.47	1.06	1.24	0.80	0.69
5/19	0.39	0.04	0.38	0.14	1.31	1.10	1.20	1.14
5/20	0.70	0.23	1.21	0.51	0.91	0.58	0.76	0.59
5/21	0.53	0.02	0.56	0.26	1.03	--	0.78	1.03
5/22	--	0.15	0.39	--	0.72	1.30	0.82	0.60
5/23	0.81	--	--	--	0.92	1.46	--	0.92
5/24	--	--	--	--	--	--	--	--
5/25	0.95	1.13	0.74	1.16	1.51	1.49	0.81	1.32
5/26	1.00	1.00	1.53	1.22	1.50	1.74	0.88	1.55
5/27	1.23	1.29	0.84	1.08	1.12	1.63	0.71	1.63
5/28	1.02	1.25	1.17	0.90	1.12	1.55	0.50	1.60
5/29	0.57	0.90	1.22	0.88	1.16	1.74	0.70	1.65
5/30	1.17	1.22	1.53	1.31	1.29	1.82	0.31	1.27
5/31	1.10	--	0.81	1.00	1.06	1.10	0.47	--
6/1	--	--	--	--	0.81	1.31	0.48	0.61
6/2	--	--	--	--	0.94	0.72	0.53	0.46
6/3	--	--	--	--	1.24	0.79	0.57	0.75
6/4	--	--	--	--	0.88	0.56	0.44	0.71
6/5	--	--	--	--	1.24	0.78	0.51	0.61
6/6	--	--	--	--	0.82	0.57	0.70	0.50
6/7	--	--	--	--	0.45	0.44	0.39	0.42
6/8	--	--	--	--	1.05	1.33	--	0.69
6/9	1.17	1.41	--	--	1.12	1.16	--	0.82
6/10	--	--	1.88	1.51	--	1.04	--	0.78
6/11	--	--	--	--	1.51	1.43	--	0.67
6/12	--	--	--	--	0.46	1.11	--	0.78

TABLE AII. 74

SERUM OSMOLARITY, Osm/l

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
5/4	0.31	0.30	0.35	0.28	0.28	0.29	0.33	0.39
5/9	--	--	--	--	--	--	0.36	--
5/11	0.31	0.31	0.34	0.31	0.28	0.30	0.28	0.28
5/18	0.34	0.28	0.30	0.28	0.28	0.30	0.31	0.30
5/25	0.30	0.33	0.36	0.29	0.32	0.33	0.33	0.30
6/1	0.30	0.31	0.31	0.32	0.31	0.36	0.29	0.32
6/8	--	--	--	--	0.28	0.41	0.34	0.28
6/10	0.38	0.34	0.29	0.29	--	--	--	--
6/13	--	--	--	--	0.27	0.33	--	0.31
Mean	0.32	0.31	0.32	0.30	0.29	0.33	0.32	0.31

TABLE AII. 75

URINE/SERUM OSMOLAR RATIO

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
4/27	4.1	3.6	2.2	3.2	2.4	2.2	2.9	1.0
4/28	2.3	3.6	2.0	3.6	8.6	2.3	2.4	0.9
4/29	1.9	2.7	3.3	2.9	3.9	3.0	4.3	1.0
4/30	2.3	3.2	3.3	3.3	4.3	-	3.6	0.6
5/1	2.6	2.7	3.4	4.0	3.2	3.6	3.4	0.6
5/2	2.6	3.0	3.8	3.7	4.7	3.4	3.5	1.1
5/3	3.0	3.5	3.9	3.5	4.1	3.1	1.8	0.7
5/4	2.3	3.6	-	5.7	4.2	1.9	3.0	0.8
5/5	-	2.9	4.3	3.8	4.1	2.4	3.2	0.4
5/6	2.5	1.9	3.1	4.1	3.3	2.0	3.4	0.3
5/7	2.4	2.6	-	4.6	2.7	1.6	3.0	0.03
5/8	2.0	3.3	3.9	3.3	3.4	3.4	2.0	0.2
5/9	3.1	3.9	2.3	4.4	4.5	3.9	3.3	1.4
5/10	-	-	-	-	-	-	-	-
5/11	1.6	3.6	3.9	1.4	3.3	3.5	3.2	1.7
5/12	-	-	-	-	3.3	3.3	3.4	1.7
5/13	2.3	0.9	2.3	1.4	4.2	3.2	2.5	1.7
5/14	1.7	0.5	2.7	0.7	3.2	3.6	1.8	1.7
5/15	1.6	0.2	0.2	1.7	3.5	4.3	4.2	2.3
5/16	1.6	-	2.3	0.6	3.6	3.1	2.5	2.3

STAT
STAT

TABLE AII. 75 (contd)

Date	Subject No.							
1953	1	2	3	12	5	6	7	8
5/17	0.8	0.1	0.8	4.1	3.3	3.1	2.5	3.3
5/18	2.7	0.5	2.6	1.6	3.7	3.8	2.5	2.2
5/19	1.2	0.1	2.7	0.5	4.5	3.3	3.8	3.7
5/20	2.2	0.7	3.8	1.7	3.2	3.0	2.4	1.9
5/21	1.7	0.1	1.8	0.9	3.6	-	2.4	3.3
5/22	-	0.5	1.2	-	2.5	3.9	2.6	1.9
5/23	2.5	-	-	-	3.2	4.4	-	3.0
5/24	-	-	-	-	-	-	-	-
5/25	3.0	3.6	2.3	3.9	5.2	4.5	2.9	4.2
5/26	3.2	3.2	4.8	4.1	5.2	5.3	2.8	5.0
5/27	3.8	4.2	2.6	3.6	3.9	4.9	2.2	5.2
5/28	3.2	4.0	3.7	3.0	3.9	5.9	1.6	5.2
5/29	1.8	2.9	3.8	2.9	4.0	5.3	2.2	5.3
5/30	3.7	3.9	4.8	4.4	4.4	5.5	1.0	4.1
5/31	3.4	-	2.5	3.3	3.7	3.3	1.5	-
6/1	-	-	-	-	2.6	4.0	1.5	2.0
6/2	-	-	-	-	3.2	2.2	1.6	1.5
6/3	-	-	-	-	4.3	2.4	1.8	2.4
6/4	-	-	-	-	3.0	1.7	1.4	2.3
6/5	-	-	-	-	4.3	2.4	1.6	2.0
6/6	-	-	-	-	2.8	1.7	2.2	1.6
6/7	-	-	-	-	1.6	1.3	1.2	1.4
6/8	-	-	-	-	3.6	4.0	-	2.2
6/9	3.6	4.5	-	-	3.9	3.5	-	2.6
6/10	-	-	5.9	5.0	-	3.2	-	2.5
6/11	-	-	-	-	5.2	4.3	-	2.2
6/12	-	-	-	-	3.6	3.4	-	2.5

TABLE AII. 76

URINARY CREATININE CLEARANCE, ml/min (2-hr Test)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/22	121	144	---	155	---	1/23	135	133	165	129
1/23	---	---	164	---	---	1/29	---	108	---	---
1/27	---	---	125	---	---	1/30	173	---	173	242
1/29	---	128	---	---	---	2/6	76	72	80	82
1/30	97	---	---	142	---	2/9	---	---	---	64
2/5	157	180	148	138	147	2/10	---	65	---	---

TABLE AII. 76 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
2/12	187	140	110	---	---	2/11	---	---	94	---
2/19	116	99	151	---	87	2/13	151	131	122	139
2/24	---	---	82	---	63	2/20	158	139	225	148
2/26	92	52	---	---	---	2/27	175	124	---	163
3/5	141	118	159	---	61	3/6	99	56	133	100
3/12	170	126	127	---	171	3/9	---	---	112	---
3/19	197	147	152	---	201	3/13	127	90	171	109
3/26	141	112	142	---	202	3/20	183	223	224	132
4/8	---	---	---	---	165	3/27	193	147	205	159
4/9	153	117	195	---	---	4/3	118	95	149	128
4/16	169	107	136	---	134	4/20	91	80	165	214
4/21	---	---	---	---	66	4/17	249	117	181	175
4/23	156	75	129	---	---	4/24	159	156	198	184
4/30	180	140	153	---	246	5/1	131	207	123	103
5/5	---	220	168	---	---	5/6	90	99	---	---
5/7	218	---	---	---	---	5/8	---	---	110	114
5/8	---	---	---	---	194	5/15	170	133	194	160
5/14	93	135	119	---	126	5/22	201	152	232	124
5/21	112	107	111	---	135	5/29	140	115	171	114
5/28	188	129	173	---	182	6/4	---	---	145	---
						6/5	180	155	---	151
						6/12	160	116	---	144

TABLE AII. 77

URINARY CREATININE CLEARANCE, ml/min (2-hr test)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/22	166	139	---	148	---	1/23	188	171	174	141
1/23	---	---	142	---	---	1/29	---	147	---	---
1/27	---	---	147	---	---	1/30	126	---	128	---
1/29	---	129	---	---	---	2/6	73	81	94	79
1/30	98	---	---	128	---	2/9	---	---	---	66
2/5	168	125	150	159	150	2/10	---	63	97	---
2/12	153	150	153	---	---	2/11	---	---	---	---
2/19	120	110	140	---	95	2/13	165	153	---	165
2/24	---	---	101	---	71	2/20	161	170	180	147
2/26	90	58	---	---	---	2/27	169	138	217	156
3/5	179	140	150	---	139	3/6	52	82	155	145

STAT

TABLE AII. 77 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
3/12	151	146	144	—	305	3/9	—	—	307	—
3/19	206	144	138	—	183	3/20	—	151	231	91
3/25	102	114	165	—	121	3/27	172	181	133	171
4/2	140	120	—	—	142	4/3	103	86	110	137
4/8	—	—	—	—	175	4/10	86	84	122	140
4/9	153	121	152	—	—	4/17	164	142	189	183
4/16	162	110	138	—	139	4/24	139	164	190	164
4/21	—	—	—	—	104	5/6	105	89	—	—
4/23	120	71	121	—	—	5/8	—	—	129	119
4/30	165	166	138	—	153	5/15	192	159	152	194
5/5	—	170	0.99	—	—	5/22	158	149	138	161
5/7	203	—	—	—	183	5/29	147	136	159	156
5/14	114	91	124	—	119	6/4	—	—	140	—
5/21	114	87	138	—	112	6/5	159	112	—	174
5/28	166	114	168	—	177	6/12	147	128	—	147

TABLE AII. 78

REACTION AND REFLEX TIMES

Subj. No.	Nutrient Mixture	Water	Reaction Time, sec: Sight Pre	Sight Exp	Sound Pre	Sound Exp	Touch Pre	Touch Exp	Reflex Time, sec. Pre	Reflex Time, sec. Exp
1	ST 0	U	.174	.213	.242	.230	.231	.202	.130	.171
2		L	.198	.210	.232	.268	.233	.165	.187	.161
3		U	.211	.217	.251	.259	.178	.206	.176	.182
12		L	.172	.225	.210	.314	.221	.217	.175	.172
5	0/100/0	L	.203	.206	.170	.183	.193	.189	.144	.146
6	1000	U	.154	.221	.165	.273	.229	.205	.158	.187
7		L	.211	.194	.215	.245	.182	.205	.185	.190
8		U	.165	.149	.178	.181	.158	.155	.158	.151
5	0/20/78	U	.175	.160	.168	.177	.171	.146	.149	.174
6	1000	L	.224	.199	.227	.219	.194	.176	.180	.177
1	15/52/33	U	.199	.204	.313	.224	.175	.174	.163	.161
2	1000	L	.200	.188	.205	.176	.207	.138	.217	.142
5		L	.173	.147	.146	.164	.152	.154	.139	.145
6		U	.171	.154	.167	.183	.153	.156	.173	.173

TABLE AII. 78 (contd)

Subj. No.	Nutrient Mixture	Water	Reaction Time, sec: Sight Pre	Sight Exp	Sound Pre	Sound Exp	Touch Pre	Touch Exp	Reflex Time Pre	Reflex Time Exp
1	0/100/0	L	.201	.167	.172	.219	.198	.190	131	.195
2	2000	U	.181	.177	.213	.163	.131	.154	.231	.187
3		L	.206	.251	.238	.301	.223	.235	.152	.187
12		U	.198	.192	.253	.242	.193	.168	.198	.200
3	2/20/78	U	.199	.176	.263	.281	.182	.173	.166	.187
12	2000	L	.157	.181	.195	.197	.159	.135	.140	.144
7	15/52/33	U	.239	—	.261	—	.238	—	.214	—
8	2000	L	.153	—	.184	—	.162	—	.178	—
1	30/0/70	L	.218	.187	.297	.199	.216	.139	.175	.208
2	2000	U	.185	.176	.233	.202	.103	.123	.140	.068
3	N 3000	L	.197	.184	.193	.201	.213	.212	.134	.113
12		U	.189	.176	.204	.209	.146	.120	.154	.120
5		L	.186	—	.093	—	.163	—	.139	—
6		L	.176	—	.182	—	.181	—	.183	—
7		U	.234	.230	.237	.208	.197	.172	.149	.176
8		L	.182	.200	.191	.232	.149	.151	.117	.181

TABLE AII. 79

JUDGEMENT OF TIME: 20 Seconds

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	6	7	8	
1/16	22.0	15.5	23.5	9.0	—	1/22	21.3	11.0	9.0	18.4
1/22	22.6	19.2	—	23.4	—	1/29	—	18.9	—	—
1/23	—	—	28.4	—	—	1/30	19.8	—	19.7	—
1/27	—	—	27.2	—	—	1/31	—	—	—	19.8
1/29	—	21.0	—	—	—	2/6	19.2	20.6	19.2	28.8
1/30	24.4	—	—	13.6	—	2/9	—	—	—	24.5
2/5	19.4	23.0	19.6	23.0	23.4	2/10	—	23.4	—	—
2/12	19.3	21.8	19.5	—	22.3	2/11	—	—	19.8	—
2/19	22.4	26.0	20.7	—	21.0	2/13	18.4	22.2	15.0	18.2
2/25	—	—	22.1	—	24.7	2/20	16.1	20.6	22.2	20.7
2/26	22.5	22.7	—	—	—	2/27	20.9	23.9	22.1	21.3
3/5	22.1	24.3	21.7	—	18.3	3/6	20.7	25.5	31.1	17.2
3/12	20.4	24.1	19.2	—	24.6	3/9	—	—	31.2	—

STAT
STAT

TABLE AII. 79 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
3/19	20.2	20.3	20.9	—	21.5	3/13	19.5	24.5	33.4	19.2
3/26	19.8	21.7	19.9	—	20.2	3/20	21.7	20.4	23.0	22.5
4/2	25.0	21.4	—	—	20.7	3/27	22.5	19.4	29.7	22.9
4/8	—	—	—	—	16.8	4/3	14.3	22.1	35.9	25.8
4/9	25.3	18.0	21.2	—	—	4/10	17.5	21.8	31.8	22.7
4/16	26.8	23.7	23.0	—	21.6	4/17	17.6	21.2	23.6	19.4
4/21	—	—	—	—	23.2	4/24	21.8	22.4	22.7	24.0
4/23	21.0	23.0	23.4	—	—	5/1	16.2	20.6	36.5	24.6
4/30	17.8	22.9	23.4	—	20.6	5/6	25.2	20.4	—	—
5/5	—	21.6	20.6	—	—	5/8	—	—	37.5	24.4
5/7	21.5	—	—	—	23.0	5/15	16.2	19.6	24.0	20.6
5/14	23.9	20.0	19.3	—	27.5	5/22	18.5	20.2	38.2	23.8
5/21	21.1	21.0	20.5	—	27.5	5/29	17.8	18.6	31.0	22.1
5/28	20.7	26.9	21.7	—	32.7	6/4	—	—	38.6	—
						6/5	19.4	27.4	—	20.4
						6/12	27.4	21.8	—	16.9

TABLE AII. 80

JUDGEMENT OF TIME: 45 SECONDS

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/16	40.0	43.0	58.0	27.0	—	1/22	53.0	25.2	37.0	42.0
1/22	53.2	42.3	—	61.0	—	1/29	—	42.5	—	—
1/23	—	—	61.4	—	—	1/30	46.7	—	48.1	—
1/27	—	—	67.8	—	—	1/31	—	—	—	49.3
1/29	—	51.4	—	—	—	2/6	51.0	48.6	49.3	53.0
1/30	54.4	—	—	46.7	—	2/9	—	—	—	60.4
2/5	39.2	48.2	45.0	57.8	52.9	2/10	—	56.1	—	—
2/12	42.8	50.5	47.3	—	57.2	2/11	—	—	40.5	—
2/19	59.6	58.7	51.1	—	45.0	2/13	46.2	51.8	41.8	43.8
2/25	—	—	47.4	—	59.2	2/20	37.5	50.3	48.3	50.5
2/26	59.4	57.3	—	—	—	2/27	48.4	53.7	53.0	53.2
3/5	71.3	58.8	57.9	—	47.6	3/6	25.4	56.6	63.3	47.0
3/12	44.0	45.5	50.0	—	46.8	3/9	—	—	70.6	—
3/19	52.2	48.1	40.8	—	47.0	3/13	44.0	56.7	76.2	55.2
3/26	48.0	49.7	44.8	—	50.8	3/20	53.7	51.7	62.4	44.8
4/2	63.5	44.2	—	—	50.0	3/27	50.5	52.2	61.6	54.5
4/8	—	—	—	—	39.8	4/3	43.9	58.0	64.0	53.5

TABLE AII. 80 (contd)

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
4/9	58.5	44.8	61.0	—	—	4/10	55.8	47.2	60.0	54.5
4/16	64.3	48.2	57.8	—	42.4	4/17	46.4	43.1	67.1	50.7
4/21	—	—	—	—	54.4	4/24	54.5	48.0	75.0	57.0
4/23	47.0	45.5	54.6	—	—	5/1	49.8	43.2	60.2	64.3
4/30	38.2	46.2	37.9	—	44.7	5/6	59.8	47.0	—	—
5/5	—	57.2	56.7	—	—	5/8	—	—	70.7	64.4
5/7	45.5	—	—	—	61.0	5/15	39.6	47.9	64.7	47.4
5/14	55.3	55.1	52.3	—	59.0	5/22	41.4	42.2	72.3	55.2
5/21	47.5	53.8	55.2	—	52.0	5/29	48.4	50.5	67.1	59.8
5/28	47.6	55.8	52.2	—	41.5	6/4	—	—	79.6	—
						6/5	49.2	67.1	—	51.1
						6/12	72.6	44.0	—	42.6

TABLE AII. 81

JUDGEMENT OF TIME: 70 SECONDS

Date	Subject No.					Date	Subject No.			
1953	1	2	3	4	12	1953	5	6	7	8
1/16	65.0	74.0	93.7	69.5	—	1/22	79.2	43.0	82.2	69.5
1/22	77.9	78.8	101.3	81.3	—	1/29	—	57.4	—	—
1/23	—	—	—	—	—	1/30	85.8	—	73.0	—
1/27	—	—	113.4	—	—	1/31	—	—	—	86.8
1/29	—	78.0	—	—	—	2/6	76.4	73.6	81.7	94.3
1/30	73.3	—	—	80.2	—	2/9	—	—	—	92.4
2/5	69.0	85.6	67.3	81.8	78.7	2/10	—	84.0	—	—
2/12	74.2	76.9	75.3	—	93.4	2/11	—	—	70.8	—
2/19	96.7	91.0	79.0	—	72.3	2/13	74.2	84.6	77.8	69.2
2/25	—	—	75.3	—	90.1	2/20	60.1	79.3	87.8	65.8
2/26	91.3	84.7	—	—	—	2/27	76.5	70.3	75.2	87.2
3/5	81.4	95.0	80.8	—	75.5	3/6	82.3	70.1	123.2	69.1
3/12	82.3	71.4	72.2	—	71.0	3/9	—	—	116.9	—
3/19	87.7	75.0	70.9	—	72.4	3/13	69.4	85.8	93.2	67.7
3/26	70.0	88.0	74.8	—	66.8	3/20	66.8	74.0	95.2	69.7
4/2	99.3	74.0	—	—	76.4	3/27	80.0	73.6	72.0	78.8
4/8	—	—	—	—	73.0	4/3	75.8	77.3	93.0	80.5
4/9	90.9	67.9	93.2	—	—	4/10	80.2	78.2	93.5	98.3
4/16	107.0	84.8	89.3	—	69.4	4/17	74.4	74.2	73.4	80.2
4/21	—	—	—	—	80.4	4/24	72.8	73.6	92.5	87.5
4/23	78.1	81.3	78.2	—	—	5/1	78.6	73.5	132.8	96.8
4/30	57.5	96.2	75.9	—	75.8	5/6	97.9	85.4	—	—

STAT

TABLE AII. 81 (contd)

Date	Subject No.					Date	Subject No.			
1953	1.	2.	3	4	12	1953	5	6	7	8
5/5	—	94.9	79.5	—	—	5/8	—	—	113.2	91.2
5/7	71.7	—	—	—	82.0	5/15	64.3	69.2	110.7	67.6
5/14	90.8	82.5	78.3	—	95.7	5/22	64.5	68.6	97.3	81.7
5/21	69.8	70.8	78.5	—	75.2	5/29	68.2	74.4	98.2	78.6
5/28	76.6	83.2	82.0	—	117.0	6/4	—	—	92.0	—
						6/5	82.0	99.0	—	77.8
						6/12	102.2	66.5	—	71.7

B. SPECIAL EXPERIMENTS

1. The Effect of Ingested Aspirin on Urine Chemistry

Salicylates frequently interfere with the measurement of substances in the urine. Since it was probable that our subjects might experience headaches, it was desirable to know if treatment with aspirin would cause any significant changes in the concentration of certain substances in the urine. Rather than testing dosages commonly used for symptomatic treatment of headache, it was decided to use large therapeutic doses.

Experiment I. Subject 9 ingested three 3.5 grains of pink A.P.C. tablets every two hours between 0900 and 2300 on the middle day of a three-day period. On each of the three days a 24-hour urinary specimen was collected and analyzed for creatinine, creatine, urobilinogen, and 17-ketosteroids. The results are summarized in Table AII. 82.

Experiment II. Subject 9 ingested 10 grains of aspirin (plain white tablets) every two hours between 0900 and 2300 on the middle day of a three-day period. On each of the three days a 24-hour urinary specimen was collected and analyzed for creatinine and creatine. The results are summarized in Table AII. 82.

TABLE AII. 82

INFLUENCE OF ASPIRIN ON URINARY CHEMISTRY

Experimental Condition	Creatinine gm/day	Creatine gm/day	Urobilinogen S.U./day	17-KS mg/day
		Experiment I		
Pre-day	1.58	0.73	8.7	3.3
A.P.C.-day	1.99	0.77	9.0	5.6
Post-day	2.24	0.72	14.1	8.3
		Experiment II		
Pre-day	2.46	0.21	—	—
Aspirin-day	1.97	0.26	—	—
Post-day	2.39	0.30	—	—

Conclusions: It is concluded that large doses of aspirin have no significant effect on creatinine and creatine. There may be a small increase in urobilinogen following ingestion of aspirin. The output of 17-ketosteroids, while unexpectedly low, does increase following ingestion of aspirin. This finding has been reported by others. On the basis of these experiments, we felt justified in allowing limited use of aspirin and aspergum for management of headaches and sore throats, respectively.

2. Urinary 17-Ketosteroids and Antipyrine

Early in the present investigation it was found that when seven-day pools of urine included urine passed on the day antipyrine and sodium thiosulfate were administered, no 17-ketosteroids could be detected. This observation meant that either antipyrine or sodium thiosulfate were interferring with the chemical analysis for 17-ketosteroids. To determine which substance was the responsible agent, subject 9 ingested orally 10 ml of 20% antipyrine on day 3 of a six-day period. This quantity was twice the dose usually given intravenously to our subjects in the determination of total body water. About five minutes after ingestion, the subject experienced burning of the tongue and nose, a characteristic symptom, lasting some 30 minutes. Twenty-four hour urines were collected for six days: two days before antipyrine and three days after antipyrine. The specimens were analyzed for 17-ketosteroids. The results summarized in Table AII. 83 indicate that antipyrine does not interfere with the chemical analysis. The offending substance is probably sodium thiosulfate. Because of this result urines collected on days that body fluid compartments were determined were not included in the seven-day pools.

STAT

TABLE AII. 83

INFLUENCE OF ANTIPYRINE ON URINARY 17-KETOSTEROID EXCRETION

Experimental Condition	17-KS mg/day
Pre-day 1	14.6
Pre-day 2	17.4
Antipyrine	20.0
Post-day 1	21.4
Post-day 2	20.6
Post-day 3	21.9

3. Acute Dehydration

Protocol. A two-phase study was made employing the cross-over technique on two alternate subjects (9 and 11) to obtain answers to three questions: (1) What is the effect of dehydration on insensible water loss? (2) What is the effect of dehydration on creatinine clearance. (3) What is the effect of dehydration on total body water? Incidental observations were planned so that the creatinine clearance calculated from a two-hour urine could be compared with the clearance calculated from a concurrent 24-hour urine and data could be obtained for studying the effects of acute dehydration on the subject's estimate of the passage of time and urinary 17-ketosteroids.

During both phases, after a pre-period of 24 hours, both subjects underwent a 72-hour fast. In each phase one subject was allowed sufficient water to keep him in positive water balance. This allowance was estimated by utilizing data on 24-hour urinary volume and 24-hour insensible water loss obtained in other experiments on these men. The subject drank one-sixth of the allowance every four hours. The other subject was allowed no water. The subjects were permitted to be ambulatory and maintain their regular academic schedules.

The following measurements were made:

1. Insensible weight loss.
2. Resting oxygen consumption and CO_2 production.
3. Serum creatinine.
4. Hematocrit.
5. 24-hour urinary volume and specific gravity.
6. Freezing point depression of serum and urine.
7. Water diuresis test (at end of 72 hours).
8. Body water determination (at end of 72 hours).
9. Estimate of passage of time (20, 45, and 70 sec.).
10. Pulse.
11. Oral Temperature.
12. Body weight.

All measurements and analyses were conducted according to the methods discussed in detail in Section II.

Phase I (14-17 May 1953). Subject 9 was allowed no water and subject 11 was given 500 ml every four hours. Except for the development of thirst by subject 9, there were no significant clinical symptoms or signs.

Phase II (28-31 May 1953). Subject 11 was allowed no water and subject 9 was given 400 ml every four hours. There was a heat wave during the course of this experiment (see Appendix V and Table AII. 86b). On day 1 subject 11 vomited 120 ml. This volume was replaced with an equal volume of water. A severe headache responded to ten grains of aspirin. On day 2 the tongue of subject 11 was coated but he did not complain much of thirst in the morning. In the afternoon he quietly became weak and tired. His speech was "thicker". His tongue was dry and coated. At 7:30 his temperature was elevated and his pulse rate ranged from 100-110. He took a cold shower for relief. Subject 9 passed normal watery stools. On day 3 subject 11 was feeling better but complained of dry mouth and thick tongue. Tongue was heavily coated. Subject rinsed mouth with water for relief and took cold shower. He had an afternoon hyperpnoea and rapid pulse (see Table AII. 86). He expressed a craving for a drink of heavily flavored water. Subject 9 passed one watery stool.

Ambient Conditions. During Phase I of this experiment, the weather was not unusual and it was possible to maintain the temperature and relative humidity close to the zone of thermal neutrality during the measurement of insensible water loss and resting metabolism (Table AII. 83). In Phase II a heat wave developed and the afternoon temperatures in the test-room exceeded the threshold for sweating (Table AII. 83). There was a concurrent large increase in the rate of insensible water loss (Table AII. 86; values bracketed). At other times the ambient conditions were comparable to those prevailing in Phase I.

Clinical Observations (Table AII. 85). Subject 9 lost 3.4 kg while fasting and thirsting and 2.3 kg while only fasting. Subject 11 lost 4.0 kg while fasting and thirsting and 1.5 kg while only fasting. Since the caloric deficits were probably constant in both phases for the two subjects, it follows that subject 9 incurred a net water deficit of 1.1 liters and subject 11 a water deficit of 2.5 liters. The hot weather undoubtedly was the principle factor responsible for the greater deficit in subject 11. The acute dehydration was not reflected by a significant change in the hematocrit. Except for the hyperpyrexia noted above in subject 11 there were not significant changes in the pulse rates or oral temperatures during the 72 hours of the experiment.

Insensible Water Loss (Table AII. 86). A period of 72 hours without water caused no greater change in the rate of insensible water loss than would have been predicted from the effect of fasting alone. Subject 9 incurred a water deficit of 1.6-1.8% of his body water, subject 11, 3.9-4.2%. The data for both men with or without water are comparable - excluding the tracketed values obtained when the ambient D. B. T. exceeded 30°C.

TABLE AII. 84

AMBIENT CONDITIONS DURING TWO-HOUR TEST

Date	No Water in Fast: Hours of fast	D.B.T. °C	W.B.T. °C	Rel. Hum. %	Date	Measured Water in Fast: Hours of fast	D.B.T. °C	W.B.T. °C	Rel. Hum. %
			Subject No. 9						
5/16	16	27.7	18.2	42	5/29	18	28.8	20.6	47
	22	27.3	18.3	41		21	(29.9)	20.6	42
5/17	39	28.5	20.6	49	5/30	39	28.6	22.4	58
	44	28.0	20.6	51		45	(31.6)	23.2	49
5/18	63	27.5	22.2	64	5/31	60	28.6	17.8	33
	71	27.5	19.9	49		70	(31.2)	17.8	25
			Subject No. 11						
5/29	17	28.3	19.4	44	5/16	17	27.8	19.2	43
	23	(30.1)	21.6	47		23	27.1	18.1	41
5/30	40	29.2	22.2	54	5/17	38	28.9	19.6	43
	46	(31.4)	22.3	44		45	27.6	21.0	55
5/31	59	27.7	18.6	42	5/18	62	26.8	23.0	72
	69	(32.1)	18.1	25		70	28.5	20.8	50

TABLE AII. 85

ACUTE DEHYDRATION: CLINICAL DATA

Date	No Water in Fast: Hours of fast	Body Wt Kg	Het Vol %	Pulse	Oral Temp °F	Date	Measured Water in Fast: Hours of fast	Body Wt Kg	Het Vol %	Pulse	Oral Temp °F
				Subject No. 9							
	Pre	-	-	-	-		Pre	-	-	-	-
5/16	16	67.3	48.0	66	98.0	5/29	16	66.6	48.0	62	97.7
	22	66.7	47.0	74	98.5		21	66.2	45.5	66	98.6
5/17	39	65.6	47.5	76	98.2	5/30	29	65.9	46.5	64	97.6
	44	65.2	48.0	74	98.5		45	65.4	45.0	58	97.4
5/18	63	64.2	49.5	56	97.4	5/31	60	64.3	45.0	58	97.4
	71	63.9	-	68	98.2		70	64.3	-	70	98.5
				Subject No. 11							
	Pre	-	-	-	-		Pre	-	-	-	-
5/29	17	63.4	44.0	78	98.1	5/15	17	63.9	44.0	74	98.6
	23	62.4	41.0	80	98.7		23	63.4	40.0	80	98.3
5/30	40	61.5	42.0	78	98.7	5/16	38	62.6	44.0	74	97.7
	46	60.7	41.0	90	99.7		45	62.5	41.0	68	98.4
5/31	59	60.0	42.5	70	98.0	5/17	62	61.8	43.0	74	97.4
	69	59.4	-	98	99.5		70	62.4	-	70	98.2

TABLE AII. 86

INSENSIBLE WATER LOSS AND METABOLISM

Date	No Water In Fast: Hours of fast	I.W. gm/hr	Pul. Vent l/min	O_2 Uptake ml/min	R.Q.	Date	Measured Water In Fast: Hours of fast	I.W. gm/hr	Pul. Vent l/min	O_2 Uptake ml/min	R.Q.
				Subject No. 9							
	Pre	28.7	-	-	-		Pre	28.7	-	-	-
5/15	16	31.8	5.26	260	0.82	5/29	18	21.3	10.05	264	0.79
	22	41.9	5.28	273	0.76		21	(82.4)	5.30	245	0.70
5/16	39	28.9	5.84	276	0.80	5/30	39	26.1	6.55	246	0.74
	44	34.9	6.14	277	0.77		45	(78.7)	5.78	254	0.73
5/17	63	37.0	6.72	264	0.71	5/31	60	31.6	5.89	253	0.93
	71	32.5	-	179	0.71		70	(117.9)	6.71	270	0.78
				Subject No. 11							
	Pre	43.4	-	-	-		Pre	43.4	-	-	-
5/29	17	43.0	6.99	244	0.83	5/15	17	45.6	4.93	251	0.81
	23	(85.0)	5.17	264	0.77		23	44.7	4.48	258	0.76
5/30	40	33.2	4.44	232	0.74	5/16	38	33.2	4.86	258	0.72
	46	(111.6)	4.80	252	0.78		45	46.7	4.79	262	0.75
5/31	59	28.3	4.56	249	0.74	5/17	62	23.0	5.30	229	0.71
	69	(69.5)	6.00	286	0.76		70	31.8	5.29	255	0.76

Resting Metabolism (Table AII. 86). Within the 72-hour period, the oxygen consumption remained remarkably constant. There was a progressive and rather consistent decline in the R.Q. which was chiefly caused by increased CO_2 production. The elevated catabolism of starvation did not however produce enough CO_2 to augment the pulmonary ventilation.

Renal Function: Creatinine Clearance (Table AII. 87). Dehydration produced a marked reduction in the 2-minute urine volume and the 24-hr. urine volume. The endogenous creatinine fell progressively during fasting in both men. This trend, however, was not significantly altered by the state of hydration confirming observations cited earlier on the regular subjects (Figure III. 29). Identical trends were noted whether the clearance was calculated from the two-hour urinary output of creatinine or the 24-hr. output, an observation confirming the validity of the two-hour test of renal function.

Renal Function: Urine / Serum Molar Ratio (Table AII. 88). The solute load of these subjects was the result of catabolism of body tissues during fasting. When thirsting the subjects had a much higher osmolar ratio than when receiving adequate water. Subject 11, who thirsted during a heat wave, developed a ratio approaching the maximal values observed in men receiving a large exogenous solute load. These data represent the remarkable concentrating ability of the kidney.

STAT

STAT

TABLE AII. 87

RENAL FUNCTION: CREATININE CLEARANCE

Date	No Water In Fast: Hours of Fast	No Water In Fast: Urine Vol ml/24 hr	No Water In Fast: Serum Creat mg %	No Water In Fast: Creatinine Clearance 2-hr ml/min	Measured Water In Fast: Date	Measured Water In Fast: Hours of Fast	Measured Water In Fast: Urine Vol ml/24 hr	Measured Water In Fast: Serum Creat mg %	Measured Water In Fast: Creatinine Clearance 2-hr ml/min	Measured Water In Fast: Creatinine Clearance 24-hr ml/min
				Subject No. 9						
5/14	Pre	1602	1.33	160		Pre	1682	-	-	-
5/15	16	1075	0.61	135	5/29	13	-	1.05	147	-
	22		0.41	139		21	1650	1.04	163	-
5/16	39		0.38	140	5/30	39	-	0.83	156	139
	44	500	0.35	132		45	1205	1.08	128	132
5/17	63	695	0.60	134	5/31	68	1445	1.05	106	126
	71		0.55	89		70		0.90	90	89
				Subject No. 11						
	Pre	2386	-	-		Pre	2386	-	-	-
5/29	27		0.70	176	5/16	17	-	0.85	184	178
	23	1570	0.41	156		23	2137	0.98	166	168
5/30	40		0.28	123	5/17	38	2225	0.99	130	132
	46	400	0.28	112		45	-	1.05	160	138
5/31	59		0.35	104		65	3060	1.00	102	95
	69	625	0.38	94	5/18	69	2945	0.89	74	86
				102				2.34	98	
				92				1.90		

TABLE AII. 88

RENAL FUNCTION: URINE / SERUM OSMOLAR RATIO

Date	No Water In Fast: Hours of Fast	Serum Osm/l.	Urine Osm/l	U/S Ratio*	Date	Measured Water In Fast: Hours of Fast	Serum Osm/l	Urine Osm/l	U/S Ratio*
			Subject No. 9						
	Pre	-	-	-	My 27/28	-	-	0.73	2.5
My 14/15	24	0.30	0.82	2.8	My 28/29	24		0.42	1.4
My 15/16	48	0.28	1.01	3.5	My 29/30	48	0.29	0.52	1.8
My 16/17	72	-	1.14	3.9	My 30/31	72	0.28	0.44	1.5
			Subject No. 11						
My 27/28	Pre	-	0.43	1.5	My 14	Pre	-	0.48	1.7
My 28/29	24	0.31	0.58	2.0	My 14/15	24		0.76	2.6
My 29/30	48	-	1.04	3.6	My 15/16	48	-	0.38	1.3
My 30/31	72	0.29	1.29	4.5	My 16/17	72	0.28	0.41	1.4

* Calculated from mean serum osmolarity:
Subject 9 = 0.29 Osm/l
Subject 11 = 0.29 Osm/l

Urinary Output of Creatinine (Table AII. 89). During the 72-hour fast there was no appreciable change in the daily output of creatinine except in subject 11 while thirsting.

Urinary Output of 17-Ketosteroids (Table AII. 89). There was a large and progressive fall in the excretion of 17-ketosteroids by subject 9 while on measured water and by subject 11 on both water regimens. It is doubtful that thirsting accentuated the stress of fasting. The response of our regular subjects (Figure III. 37) likewise indicated that under a variety of different conditions limitation of water generally evoked no greater decrease in the 17-Ks excretion than did unlimited water. A remarkable observation was the rebound in 17-Ks shown by subject 11 after thirsting. A similar rebound was observed in subject 8 (Figure III. 36) who became ill while on limited water at the same time subject 11 was thirsty. One is tempted to incriminate the heat wave as the factor accentuating the dehydration of both these men and thus bringing about the elevation of 17-Ks to levels exceeding the range of normal.

Passage of Time (Table AII. 90). The two subjects made opposite estimates of the passage of time: No. 9 overestimated the passage of time, No. 11 underestimated it. Regardless of these differences two trends are evident. Thirsting plus fasting tended to produce a progressive increase in the estimates of the 45- and 70-second intervals. Fasting plus measured water tended to produce a decrease in the estimates of these same intervals. Observations made on the regular subjects likewise suggested that limitation of water increased the estimate of the passage of time. What the mechanism of this psychobiological phenomenon is cannot be stated. Certainly the observation warrents further study.

TABLE AII. 89

ACUTE DEHYDRATION: DAILY OUTPUT OF CREATININE AND 17-KETOSTEROIDS

Subject	Hours of Fast	No Water In Fast Creatinine gm/day	No Water In Fast 17-KS mg/day	Measured Water In Fast Creatinine gm/day	Measured Water In Fast 17-KS mg/day
9	Pre	-	-	1.90	12.1
	24	1.69	11.4	1.58	8.8
	48	1.58	12.6	2.00	7.3
	72	1.90	10.2	1.92	5.0
	Post*	-	-	1.80	6.6
11	Pre	3.08	13.6	-	20.6
	24	2.21	17.7	2.18	12.5
	48	1.88	12.3	1.99	12.2
	72	1.98	11.0	1.85	-
	Post*	2.81	28.6	-	-

*Fifth day post-starvation.

TABLE AII. 90

ACUTE DEHYDRATION: PASSAGE OF TIME

Date	No Water In Fast Hours of Fast	Time (sec.) 20	45	70	Date	Measured Water In Fast Hours of Fast	Time (sec.) 20	45	70
				Subject No. 9					
	Pre*	20.4	50.0	73.7		Pre	20.4	50.0	73.7
5/16	16	21.0	61.4	78.8	5/29	18	27.0	66.5	120.0
	22	25.0	54.1	87.0		21	26.8	62.8	99.7
5/17	39	21.5	58.4	86.4	5/30	39	27.0	61.7	104.0
	44	22.6	54.1	84.0		45	22.2	49.7	89.0
5/18	63	23.7	64.4	82.1	5/31	60	22.0	55.6	87.5
	71	21.3	52.6	88.6		70	22.4	54.8	87.3
				Subject No. 11					
	Pre	-	-	-		Pre	-	-	-
5/29	17	15.0	33.6	49.2	5/16	17	17.2	34.8	62.4
	23	15.6	34.9	52.5		23	16.2	36.9	55.4
5/30	40	17.1	35.4	53.0	5/17	38	16.3	39.2	60.1
	46	14.4	36.1	62.8		45	15.1	34.3	52.6
5/31	59	15.4	31.7	58.4	5/18	62	16.4	35.2	57.3
	69	14.6	35.6	58.8		70	14.0	34.3	51.7

* Data taken from another experiment on this subject.

Water Diuresis (Table AII. 91). Among the several observations which stimulate the hypothesis that the reaction of the human being to oral ingestion of water is largely conditioned by the state of hydration of the tissues are the results summarized in Table AII. 91. When the fasting subjects had thirsted for 72 hours, neither showed any diuretic reaction to an oral water load of 20 ml/kg. The specific gravity and the hourly urine flow did not alter significantly from the pre-test value. When allowed adequate water, the fasting subjects showed typical diuresis. The response of subject 9 was most dramatic. Subject 11 may have been a little dehydrated for his initial specific gravity was low and urine volume high. A diuretic followed the ingestion of water but there was only a small decrease in the specific gravity.

TABLE AII. 91

ACUTE DEHYDRATION AND WATER DIURESIS (20 ml/kg in First Hour)

Subject	Time	No Water In Fast Urine Sp. gravity	No Water In Fast Urine Vol. ml/hr	Measured Water in Fast Urine Sp. gravity	Measured Water in Fast Urine Vol. ml/hr
9	Pre-test	1.034	33	1.030	55
	1st hr.	1.034	31	1.018	117
	2nd hr.	1.034	31	1.006	470
	3rd hr.	1.034	31	1.011	295
	4th hr.	1.035	35	1.024	55
11	Pre-test	1.042	25	1.009	275
	1st hr.	1.041	25	1.007	370
	2nd hr.	1.039	35	1.007	430
	3rd hr.	1.035	29	1.008	220
	4th hr.	1.035	27	1.012	108

Total Body Water (Table AII. 92). To determine whether significant changes had been produced in total body water by acute water deprivation, the antipyrine space was determined on the last day of the 72-hour period. The data are summarized in Table AII. 92. The control data were obtained when the two subjects were living under unrestricted conditions. Fasting alone produced a decrease of 3.3 (No. 9) and an increase of 4.7 (No. 11) liters of antipyrine space. With fasting and acute water deprivation the antipyrine space decreased 2.4 (No. 9) and 7.8 (No. 11) liters. Subject 9 lost less water when allowed no water than when allowed water. Subject 11 lost more water during the period of acute water restriction. Although the data on subject 9 are difficult to interpret because of the clinical complications, the evidence for subject 11 strongly suggests marked dehydration.

Comment. Both subjects became acutely dehydrated as a result of the experimental conditions. The dehydration was indicated by (1) reduction in urine/flow/unit time, (2) increased urine/serum osmolar ratio, (3) reaction to water diuresis test, and (4) change in body weight. The degree of dehydration was quite comparable

STAT
STAT

to that produced more slowly in the regular subjects. The dehydration was of the order of 5% of the body weight and just sufficient to initiate the characteristic symptoms of the dehydration syndrome. Under these conditions there was (1) no significant change in insensible water loss, (2) no significant change in creatinine clearance, and (3) an increasing tendency to overestimate the passage of time.

TABLE AII. 92

CHANGE IN ANTIPYRINE SPACE* DURING FASTING AND ACUTE WATER DEPRIVATION

	Subject 9		Subject 11	
Regimen	Liters	%H2O**	Liters	%H2O**
Control	35.6	53.7	33.6	51.6
No food, no water	33.2	51.5	25.8	42.8
No food, water	32.3	50.3	38.3	61.7

* Antipyrine space may or may not be equivalent to total body water; data correlate highly with D_2O space in normal men but few data are available on dehydrated men.

** % body weight due to water.

4. The Meat Bar

Because of the strikingly different clinical reactions of subjects 7 and 8 to 1000 Cal/day of meat bar (30/0/70) — subject 7 was on limited water and deteriorated rapidly in contrast to subject 8 who was on unlimited water and fared much better — a special study of this diet was undertaken. The chief aim was to find if restriction of water was the factor responsible for the clinical changes in subject 7.

Experimental Design. Three subjects (A.A.P. and alternates 10 and 11) were used. The cross-over technic was employed with A.A.P. remaining as a constant control: week 1, regular diet; week 2, meat bar with A.A.P. and No. 11 on unlimited water and No. 10 on restricted water; week 3, regular diet; week 4, meat bar with A.A.P. and No. 10 on unlimited water and No. 11 on restricted water. Unfortunately No. 10 became ill with a condition unrelated to the regimen early in week 4 and had to be hospitalized.

The time table of the tests was as follows:

Week 1 (23 - 30 March)
Thurs., March 26: 2-hour function test (1000-1200).
Fri. - Sat., March 27-28: collect 24-hour urine.
Sun., March 29: water diuresis test.

Week 2 (30 March - 6 April)
Meat bar diet commences with morning meal on Monday.

No. 10; 1000 Cal, 500 ml of water per 24-hour period; No. 11, 1000 Cal, water unlimited but measured; A.A.P., 1000 Cal, water unlimited but measured.
Fasting blood will be drawn Monday morning before breakfast. 24-hour urine will be collected daily and collection times noted, for this entire week.
Thurs., April 2: 2-hour function test (1000-1200).
Sat., April 4: T.V. body water test.
Sun., April 5: water diuresis test.

Week 3 (6 - 13 April)
Free feeding. Fasting blood sample Monday morning; remainder of week same as week 1.

Week 4 (13 - 20 April)
Meat bar: No. 10, 1000 Cal, unlimited but measured water; No. 11, 1000 Cal, 500 ml of water per day; A.A.P., 1000 Cal, unlimited but measured water.
Fasting blood drawn Monday morning before breakfast. The remainder of this week will be exactly like week 2.

Body Weight. Reference to Table AII. 93 indicates that regularly limited water caused a greater weight loss than did unlimited water. A.A.P. lost 4.4 kg of body weight and No. 11 lost 2.8 kg during week 2 on unlimited water. Subject No. 10, on limited water lost 5.9 kg. Assuming approximately similar caloric balances, No. 10 lost 5.9 - 3.6 = 2.3 kg of body water, a dehydration of about 1.7%. In week 4, A.A.P. lost 3.5 kg of body weight on unlimited water and No. 11 5.2 kg on limited water. Subject No. 11 thus lost about 5.2 - 3.5 or 1.7 kg of body water, a dehydration of about 2.7%. Thus this degree of restriction of water caused a dehydration of the order of 2% of the body weight in seven days.

Urine Volume and Specific Gravity. The daily urinary volumes and specific gravities measured during the two seven-day periods on the meat bar diet are summarized in Table AII. 94. Restriction of water reduced the urine volume of subject 10 to about 0.8 l/day and elevated the specific gravity to over 1.030. Under the same circumstances, subject 11 excreted 0.9 l/day and the specific gravity rose to about 1.025.

Water Diuresis Test. The water diuresis test was administered to each of the three subjects on day 7 of each of the four weeks. It was conducted in an identical fashion to that given the regular subjects (Section II). The results are summarized in Tables AII. 95, 96 and 97. Subject A.A.P. who was on unlimited water throughout the experiment showed a good diuretic response in each test-period. Although the changes in the hourly specific gravities were remarkably consistent, there was rather wide variability in the hourly urinary outputs. The meat bar regimen per se seemed to have had little effect on these changes. Subject 10 had a definite diuresis in both weeks 1 and 3. Except for the sustained diuresis in the 4th hour of week 1, the two tests were quite similar. On the meat bar with restriction of water, there was no diuresis. Both the urinary volumes and the specific gravities remained remarkably constant. Accordingly, we conclude that this subject was dehydrated. Subject 11 had rather consistent diuretic responses during weeks 1 and 3. In week 2, when he was on the meat bar with unrestricted water, there was also a diuresis, but it was not sustained. Both the rate of urinary flow and the specific gravities

TABLE AII. 93

CHANGE IN BODY WEIGHT ON 30/0/70 1000: UNRESTRICTED WATER INTAKE VS. 900 ml/DAY

Date	Dietary Regimen	A.A.P.	Subject No. 10	No. 11
Mar. 29	Regular	83.2	78.6	63.8
30	30/0/70	82.7	-	-
31		82.5	78.6*	63.3
Apr. 1		81.0	76.0	62.7
2		80.5	75.3	62.2
3		80.1	74.3	62.0
4		79.5	74.0	61.6
5		79.3	72.7	61.0
6	Regular	78.3	73.7	60.4
7		81.0	76.5	63.0
8		82.0	77.6	63.8
9		82.0	-	64.4
10		-	-	63.8
11		-	-	63.5
12		-	77.8	63.8
13	30/0/70	81.5	79.5	63.5
14		81.3	-	62.5
15		80.2	-	61.0
16		79.8	-	61.0
17		78.9	-	60.0
18		78.4	-	59.3
19		78.0	-	58.7
20		78.0	-	58.2

Underlined weights refer to limited water regimen.

TABLE AII. 94

CHANGE IN 24-HR URINARY VOLUME AND SPECIFIC GRAVITY ON 30/0/70-1000 UNRESTRICTED WATER VS. 900 ml/DAY

Date	A.A.P. 24-hr Volume ml	A.A.P. Specific Gravity	No. 10 24-hr Volume ml	No. 10 Specific Gravity	No. 11 24-hr Volume ml	No. 11 Specific Gravity
Mar. 30	750	1.029	870*	1.029	2250	1.009
31	1495	1.018	735	1.030	-	1.009
Apr. 1	1120	1.017	825	1.029	1975	1.013
2	1415	1.017	735	1.032	-	1.011
3	1630	1.014	775	1.032	2420	1.009
4	1330	1.018	770	1.039	1810	1.021
5	(1795)**	(1.011)	(1115)	(1.028)	(2275)	(1.009)
13	1570	1.013	-	-	850	1.024
14	1535	1.016	-	-	760	1.027
15	1310	1.016	-	-	810	1.027
16	1460	1.018	-	-	760	1.023
17	1315	1.017	-	-	1010	1.012
18	1115	1.017	-	-	1155	1.024
19	(2390)	(1.006)	-	-	(1070)	(1.018)

* Underlined values refer to limited water regimen.
** Values in parentheses for data on days of water diuresis test.

TABLE AII. 95

WATER DIURESIS TEST, A.A.P.: REGULAR DIET VS. 30/0/70 1000

Diet	Hour of Test	Flow, ml/hr Week 1	Flow, ml/hr Week 3	Specific Gravity Week 1	Specific Gravity Week 3
Regular Water: U	Pre	47	70	1.025	1.023
	1st	76	84	1.022	1.017
	2nd	485	615	1.004	1.004
	3rd	545	440	1.005	1.004
	4th	70	260	1.012	1.018
		Week 2	Week 4	Week 2	Week 4
30/0/70 1000 Water: U	Pre	108	61	1.019	1.023
	1st	33	50	1.019	1.019
	2nd	192	660	1.004	1.005
	3rd	195	340	1.004	1.005
	4th	220	26	1.006	1.015

STAT
STAT

TABLE AII. 96

WATER DIURESIS TEST, NO. 10: REGULAR DIET VS. 30/0/70 1000

Diet	Hour of Test	Flow, ml/hr Week 1	Week 3	Specific Gravity Week 1	Week 3
Regular Water: U	Pre	23	46	1.034	1.024
	1st	74	126	1.016	1.011
	2nd	500	460	1.006	1.004
	3rd	515	415	1.006	1.004
	4th	256	38	1.006	1.018
		Week 2	Week 4	Week 2	Week 4
30/0/70 1000 Water: L in Week 2	Pre	26	-	1.031	-
	1st	26	-	1.030	-
	2nd	30	-	1.028	-
	3rd	22	-	1.029	-
	4th	20	-	1.035	-

TABLE AII. 97

WATER DIURESIS TEST, NO. 11
REGULAR DIET VS. 30/0/70 1000

Diet	Hour of Test	Flow, ml/hr Week 1	Week 3	Specific Gravity Week 1	Week 3
Regular Water: U.	Pre	25	68	1.024	1.021
	1st	71	104	1.017	1.018
	2nd	590	805	1.004	1.004
	3rd	152	290	1.008	1.005
	4th	56	46	1.013	1.021
		Week 2	Week 4	Week 2	Week 4
30/0/70 1000 Water: U in Week 2; L in Week 4	Pre	33	41	1.022	1.019
	1st	48	49	1.017	1.019
	2nd	258	46	1.004	1.020
	3rd	58	41	1.011	1.019
	4th	61	38	1.015	1.020

rapidly returned toward the pre-test values after the 3rd hour. When the water was restricted, the response was qualitatively similar to that of subject 10: the urinary volume and specific gravity were sustained remarkably constant. The curious findings were the larger urinary volumes and the lower specific gravities. A similar difference between these two subjects occurred in the case of the 24-hour urines. The reason for this difference is not evident, for in a later experiment involving fasting and thirsting subject 11, when dehydrated, then related to the water diuresis test just as did subject 10 in the present experiment. (See Table AII. 91). On the basis of the reaction, we can conclude that subject 11 was dehydrated.

Among the several ways in which the data of this test may be analyzed, one is to calculate the per cent recovery of the oral water load during the subsequent four hours according to the formula:

$$\text{Per Cent Recovery} = 100 \times \frac{\Sigma \text{ of four hourly urine vols} - 4 \times \text{pre-test vol}}{\text{oral load}}$$

These recoveries are tabulated in Table AII. 98. Three conclusions may be drawn from the data. (1) When the subject is on 2500 ml/day of water, the recovery is negligible. (2) When the subject is on unlimited water, there is a definite tendency for lower recoveries to occur with 30/0/70 1000 than with the regular diet. (3) There is considerable inter- and intra-individual variability in the response when the water-intake is not restricted. This fact would suggest that more reproducible observations would obtain if the regimen of unlimited water were actually fixed at some adequate level; e.g., 2500 ml/day.

TABLE AII. 98

PER CENT RECOVERY OF ORAL WATER LOAD IN FOUR HOURS

Diet	Subject A.A.P. No. 10	No. 11	
Regular, U.	59	80	60
30/0/70 1000 U.	13	—	24
30/0/70 1000 L.	—	0	—
Regular, U.	69	58	76
30/0/70 1000 U.	54	—	—
30/0/70 1000 L.	—	—	1

Total Body Water (Extracellular Space). The total body water was measured in each of these subjects on the 4th day of the regimen of 30/0/70 1000. Control values were obtained after the subjects had fully recovered from the experiment. It is evident (Table AII. 99) that, even with unlimited water, the 30/0/70 1000 regimen causes both a relative (% body weight) and absolute (liters) decrease in

the antipyrine space. This result collaborates the conclusion drawn from the data on per cent recovery of oral water load and strengthens the hypothesis that the water diuresis test may be a good measure of dehydration. Restriction of water caused, in subject 11, a further decrease of 2.2 liters, a value corresponding closely to the 1.7 liters predicted from changes in body weight.

TABLE AII. 99

ANTIPYRINE SPACE: CONTROL VS 30/0/70 1000

Diet	A.A.P. % Body Wt	A.A.P. Liters	No. 10 % Body Wt	No. 10 Liters	No. 11 % Body Wt	No. 11 Liters
Control	46.5	38.6	49.0	37.9	51.8	33.6
30/0/70 1000 U	40.0	31.8	-	-	42.7	26.3
30/0/70 1000 L	-	-	42.5	31.1	39.4	24.1

Change in body water on 30/0/70 1000 U, No. 11 = 7.3 l.
Change in body water on 30/0/70 1000 L, No. 11 = 9.5 l.

Clinical Pathology. In addition to the studies of the dehydrating effects of the 30/0/70 1000 nutrient mixture, a variety of information was collected regarding concurrent changes in blood and urinary chemistry, and hematology. These observations will be summarized in the following paragraphs.

Hematology: The hematological observations are detailed in Tables AII. 100 and 101. (1) No significant changes occurred in the red cell count. (2) Small increases in the hemoglobin concentration and hematocrit occurred in the subjects during dehydration. (3) The erythrocyte sedimentation rate was regularly accelerated during subsistence on the meat bar regimen. This latter finding confirms observations made on two other subjects (Section III) subsisting on this same regimen. (4) All subjects exhibited a small increase in the white blood cell count during the meat bar regimen. An increase in the per cent of neutrophils and decrease in per cent lymphocytes suggested that the increase was a relative neutrophilic leukocytosis. (5) No significant change was noted in the direct eosinophil count. (6) The monocytes, eosinophils, and basophils of the differential did not change. On the basis of these observations, it would seem that the relative lymphocytosis shown by subject 7 (Section III) was an individual idiosyncrasy.

Blood chemistry: The data on serum cholinesterase, plasma CO_2 combining power, and serum creatinine are summarized in Table AII. 102. (1) The serum cholinesterase tended to rise during the first exposure to meat bar, fall during the second period of regular diet (recovery) and then rise again during the second exposure to meat bar. This lag in the fall is similar to that observed in subjects recovering on 5-in-1 ration (Section III). (2) During each exposure to meat bar there was a small decrease in the CO_2 combining power. In spite of the marked ketonuria, there was no serious acidosis. (3) Subsistence on meat bar caused a consistent rise in the serum creatinine.

TABLE AII. 100

HEMATOLOGICAL OBSERVATIONS. I: REGULAR DIET VS. 30/0/70 1000

Date	Diet	A.A.P. R.B.C. mil/mm³	A.A.P. Hb. gm/100 ml	A.A.P. Hct. %	A.A.P. Corr. E.S.R. mm/hr	Subject No. 10 R.B.C. mil/mm³	Subject No. 10 Hb. gm/100 ml	Subject No. 10 Hct. %	Subject No. 10 Corr. E.S.R. mm/hr	Subject No. 11 R.B.C. mil/mm³	Subject No. 11 Hb. gm/100 ml	Subject No. 11 Hct. %	Subject No. 11 Corr. E.S.R. mm/hr.
26 Mar.	Regular	4.86	14.8	48.0	13.0	4.85	15.2	49.0	10.0	4.90	16.1	49.0	11.0
2 Apr.	30/0/70 1000 U	4.85	15.2	47.0	19.0	-	-	-	-	4.85	16.1	48.0	13.0
	30/0/70 1000 L	-	-	-	-	5.15	17.0	51.0	15.0	-	-	-	-
10 Apr.	Regular	4.76	14.8	45.0	15.0	5.05	16.6	49.0	9.0	4.68	14.1	43.0	21.0
17 Apr.	30/0/70 1000 U	4.85	15.2	47.0	15.0	-	-	-	-	-	-	-	-
	30/0/70 1000 L	-	-	-	-	-	-	-	-	4.65	14.8	46.0	13.0

Abbreviations:
R.B.C. = Red blood cell count
Hb. = Hemoglobin
Hct. = Hematocrit (packed red cell volume)
Corr. E.S.R. = Erythrocyte sedimentation rate (corrected to an hematocrit of 47%).

TABLE AII. 101

HEMATOLOGICAL OBSERVATIONS, II:
REGULAR DIET VS. 30/0/70 1000

Date	Diet	W.B.C. cells/ mm3	Direct Eos. cells/ mm3	Differential N	L	M	E	B
			A.A.P.					
26 Mar.	Regular	7250	166	35	52	0	9	4
2 Apr.	30/0/70 1000 U	8350	155	48	50	0	2	0
10 Apr.	Regular	6500	155	39	45	0	5	2
17 Apr.	30/0/70 1000 U	7300	178	43	52	0	5	0
			No. 10					
26 Mar.	Regular	7000	44	55	44	0	1	0
2 Apr.	30/0/70 1000 L	7750	133	53	46	0	1	0
10 Apr.	Regular	6500	122	52	46	0	2	0
			No. 11					
26 Mar.	Regular	8100	33	55	44	0	1	0
2 Apr.	30/0/70 1000 U	9050	44	63	34	1	2	0
10 Apr.	Regular	7000	166	42	53	0	4	1
17 Apr.	30/0/70 1000 L	9000	56	56	40	1	2	1

Abbreviations:

W.B.C. = White blood cell count
Direct Eosin = Direct eosinophil count
N = Neutrophil
L = Lymphocyte
M = Monocyte
E = Eosinophil
B = Basophil

TABLE AII. 102

OCD CHEMICAL OBSERVATIONS:
REGULAR DIET VS. 30/0/70 1000

Date	Diet	A.A.P. ChE pH/ hr	A.A.P. CO_2 ml/ 100 ml	A.A.P. Creat mg/ 100 ml	No. 10 ChE pH/ hr	No. 10 CO_2 ml/ 100 ml	No. 10 Creat mg/ 100 ml	No. 11 ChE pH/ hr.	No. 11 CO_2 ml/ 100 ml	No. 11 Creat mg/ 100 ml
26 Mar.	Regular	-	-	1.35	-	-	1.25	-	-	1.25
30 Mar.		0.84	46.1	-	1.24	40.1	-	0.71	42.7	-
2 Apr.	30/0/70 1000 U	-	-	1.58	-	-	-	-	-	1.77
6 Apr.		0.85	40.4	-	-	-	-	0.74	36.5	-
2 Apr.	30/0/70 1000 L	-	-	-	-	-	1.85	-	-	-
6 Apr.		-	-	-	1.41	39.0	-	-	-	-
10 Apr.	Regular	-	-	1.25	-	-	1.16	-	-	1.16
13 Apr.		0.81	47.1	-	1.00	42.6	-	0.64	39.5	-
17 Apr.	30/0/70 1000 U	-	-	1.37	-	-	-	-	-	-
20 Apr.		0.80	39.1	-	-	-	-	-	-	-
17 Apr.	30/0/70 1000 L	-	-	-	-	-	-	-	-	1.35
20 Apr.		-	-	-	-	-	-	0.73	36.8	-

Abbreviations:

ChE = Serum cholinesterase
CO_2 = Plasma CO_2 combining power
Creat = Serum creatinine

Urinary chemistry: Qualitative tests for albumen, sugar, and urobilinogen were regularly negative. Ketonuria was marked during subsistence on the meat bar. All three subjects had reactions ranging from 3 to 4 plus during the last four or five days of the regimen.

Data on creatinine clearance were available for two subjects: A.A.P. and No. 11. Both subjects showed a decrease in the clearance during subsistence on the meat bar (Table AII. 103). Comparable changes were noted in the regular subjects (Section III).

No significant changes were observed in the two hour output of urobilinogen (Table AII. 104).

Subsistence on the meat bar regularly caused an increase in the two-hour output of ammonia (Table AII. 105).

TABLE AII. 103

RENAL FUNCTION. REGULAR DIET VS. 30/0/70 1000

Date	Diet	Urinary Flow ml/min	A.A.P. Urinary Creat mg/min	Clearance ml/min	Urinary Flow ml/min	No. 11 Urinary Creat mg/min	Clearance ml/min
26 Mar.	Regular	1.65	1.92	142	-	-	-
10 Apr.	Regular	3.46	1.56	125	3.79	1.90	164
17 Apr.	30/3/70 1000 U	0.64	1.52	111	-	-	-
	30/0/70 1000 L	-	-	-	0.69	1.44	107

TABLE AII. 104

URINARY UROBILINOGEN AND AMMONIA

Date	Diet	A.A.P. Urobilinogen E.U./2 hr	A.A.P. Ammonia N mg/2 hr	No. 10 Urobilinogen E.U./2 hr	No. 10 Ammonia N mg/2 hr	No. 11 Urobilinogen E.U./2 hr	No. 11 Ammonia N mg/2 hr
26 Mar.	Regular	0.87	54.1	1.11		0.46	16.3
2 Apr.	30/0/70 1000 U	0.68	92.6	-	-	0.96	155.5
	30/0/70 1000 L	-	-	0.52	62.6	-	-
9 Apr.	Regular	0.65	47.4	0.27	12.7	1.58	69.6
16 Apr.	30/0/70 1000 U	0.50	61.3	-	-	-	-
	30/0/70 1000 L	-	-	-	-	0.58	75.1

One 24-hour urinary specimen in each of the four weeks was analyzed for total nitrogen and chloride (Table AII. 105). The intake of nitrogen during subsistence on 30/0/70 was 12.0 gm/day. Data are not available for calculating an accurate balance, but it is evident that the subjects were in negative nitrogen balance during both periods. The nitrogen intake in the control periods is unknown. The output of urinary chloride (calculated as NaCl) was markedly reduced during periods on the meat bar. The outputs were comparable to those measured on other subjects on comparable diets.

TABLE AII. 105

URINARY TOTAL NITROGEN AND NaCl
REGULAR DIET VS. 30/0/70 1000

Date	Diet	A.A.P. Total Nitrogen gm/day	A.A.P. NaCl gm/day	Subject No. 10 Total Nitrogen gm/day	Subject No. 10 NaCl gm/day	Subject No. 11 Total Nitrogen gm/day	Subject No. 11 NaCl gm/day
27 Apr.	Regular	-	-	21.8	27.6	12.0	13.9
2 Apr.	30/0/70 1000	20.4	1.2	19.1	2.1	14.8	1.2
10 Apr.	Regular	13.7	13.0	17.8	15.4	13.3	20.3
17 Apr.	30/0/70 1000	2.5	4.4	-	-	18.4	4.2

Clinical Observations. Subjects 10 and 11 had no particular difficulties with this regimen. While on restricted water, they both became thirsty and complained of a dry mouth. Their speech became thick and their saliva was reduced in volume and more viscous in consistency. Subject A.A.P. experienced nausea and vomiting at the end of the seven days exposure to meat bar. The reason for these symptoms in this individual was not clear. It is possible that he had a greater caloric deficit - he was in charge of the experiment in addition to his duties with the regular subjects.

Conclusions. These observations generally support the results obtained on subjects 7 and 8. They indicate that meat bar caused dehydration, mild acidosis, and ketosis. The intense clinical deterioration of subject 7 was possibly an individual idiosyncrasy. The present men showed no such progressive deterioration. Probably dehydration accentuated the ill effects of the regimen insofar as subject 7 was concerned.

C. STATISTICAL ANALYSIS OF DATA ON TOTAL SERUM CHOLESTEROL
(Dr. L. J. Warter)

The data on cholesterol (total) during the experimental periods are given in Table AII. 106. The two values for each subject are values at the end of the first and second weeks, respectively, of the experimental period. Two difficulties arise in the statistical analysis of these data: (1) there are large individual differences which cannot be separated in the analysis of variance because of confounding with other effects, (2) there appears to be a trend or cyclical variation in the pre-period values.

To eliminate the effect of individual differences, each subject is used as his own control. The pre-period cholesterol value for each subject are given in Table AII. 107. Table AII. 108 gives the experimental cholesterol as a percentage of the pre-period average for each subject. Table AII. 109

summarizes the data of Table AII. 108. Table AII. 110 shows the analysis of variance for the data of Table AII. 108. Both of the main effects (diets and caloric levels) and their interaction are significant at the 1% level, according to this analysis. A t-test shows that cholesterol is significantly higher at the 1% level for the subjects on 1000 Calories of meat bar and cereal biscuit than for those on the 2000 Calorie level.

Since there is no clinical explanation of some of the significant results found in Table AII. 110, the question arises whether or not they may really be due to cyclical variation of the sort shown in the pre-period values. This question can be answered by a new analysis which eliminates cyclical variation as well as individual differences. Table AII. 111 gives the pre-period cholesterol values for each subject as percentages of the average for that individual. The cyclical indices C for each phase are found by averaging these percentages for all subjects for that phase. Table AII. 112 gives the experimental cholesterol as percentage of cyclical normal, as found by multiplying the values in Table AII. 108 by the values of 100/C from Table AII. 112 for the phase in which the subject concerned subsisted on the particular diet involved. Table AII. 113 summarizes the data of Table AII. 112. Table AII. 114 gives the analysis of variance for the data of Table AII. 112. The difference between diets is still significant at the 1% level, but the difference between caloric levels is not significant, and the interaction is even less than one would expect by chance. Thus one may conclude that the apparent significant effects of caloric level and interaction found in Table AII. 110 are really due to cyclical variation. Individuals on the same diet are still significantly different, even though much of the difference has been eliminated by using each as his own control.

TABLE AII. 106

EXPERIMENTAL CHOLESTEROL (TOTAL)

STARVATION

Subject 1	Subject 2	Subject 3	Subject 12
219	213	121	174
237	213	106	153
Subject 5	**Subject 6**	**Subject 7**	**Subject 8**
184	120	252	165
165*	121	206	219**

*Starved only 7 days **Starved only 8 days

POSITIVE CONTROL

Subject 1	Subject 2	Subject 3	Subject 12
182	224	205	198
179	214	168	153
Subject 5	**Subject 6**	**Subject 7**	**Subject 8**
194	160	290	299
183	153	307	275

TABLE AII. 106 (contd)

CHO (1000 Cal.)

Subject 5	Subject 6	Subject 7	Subject 8
213	153	203	190
175	153	217	241

CHO (2000 Cal.)

Subject 1	Subject 2	Subject 3	Subject 12
190	237	160	106
172	109	129	82

Meat Bar (1000 cal.)

Subject 7	Subject 8
383	367
330	430

Chocolate Bar (1000 cal.)

Subject 5	Subject 6
213	205
229	168

Meat Bar (2000 cal.)

Subject 1	Subject 2	Subject 3	Subject 12
337	399	129	172
330	390	122	137

Chocolate Bar (2000 Cal.)

MEAT BAR AND CEREAL BISCUIT (1000 Cal.)

Subject 1	Subject 2	Subject 5	Subject 6
290	318	275	237
290	322	233	172

MEAT BAR AND CEREAL BISCUIT (2000 Cal.)

Subject 3	Subject 4	Subject 7	Subject 8
145	280	213	245
102	256	283	283

TABLE AII. 107

PRE-PERIOD CHOLESTEROL (TOTAL)

Subject 1	Subject 2	Subject 3	Subject 4	Subject 12
176	176	156	298	
210	213	144	258	
172	121	109		116
275	296	199		168
267	290	148		145
157	233	129		122
Sum 1257	1345	885	556	551
Average 209.5	221.5	149.33	278	137.75

TABLE AII. 107 (contd)

	Subject 5	Subject 6	Subject 7	Subject 8
	172	161	247	190
	141	138	211	175
	237	175	267	267
	221	183	275	314
	229	190	275	266
	183	183	283	229
Sum	1143	1030	1558	1441
Average	197.17	171.67	259.67	240.17

TABLE AII. 108

EXPERIMENTAL CHOLESTEROL (TOTAL) AS PERCENTAGE OF PRE-PERIOD AVERAGE

STARVATION

Subject 1	Subject 2	Subject 3	Subject 12
105	96	81	126
113	96	71	111
218	192	152	237

Subject 5	Subject 6	Subject 7	Subject 8
93	70	97	69
84	70	79	91
177	140	176	160

POSITIVE CONTROL

Subject 1	Subject 2	Subject 3	Subject 12
87	101	137	144
85	97	113	111
172	198	250	255

Subject 5	Subject 6	Subject 7	Subject 8
98	93	112	124
93	89	118	114
191	182	230	238

CHO (1000 Cal.)

Subject 5	Subject 6	Subject 7	Subject 8
108 197	89 178	109 193	79 179
89	89	84	100

TABLE AII. 108 (contd)

CHO (2000 Cal.)

Subject 1	Subject 2	Subject 3	Subject 12
91 173	107 196	107 193	77 137
82	89	86	60

MEAT BAR (1000 Cal.)

CHOCOLATE BAR (1000 Cal.)

Subject 7	Subject 8	Subject 5	Subject 6
147 274	153 332	109 224	119 217
127	179	116	98

MEAT BAR (2000 Cal.)

CHOCOLATE BAR (2000 Cal.)

Subject 1	Subject 2	Subject 3	Subject 12
168 326	180 356	86 168	125 224
158	176	82	99

MEAT BAR AND CEREAL BISCUIT (1000 Cal.)

Subject 1	Subject 2	Subject 5	Subject 6
138 276	144 289	139 257	138 238
138	145	118	100

MEAT BAR AND CEREAL BISCUIT (2000 Cal.)

Subject 3	Subject 4	Subject 7	Subject 8
97 165	101 193	82 191	102 220
68	92	109	118

TABLE AII. 109

SUMMARY OF TABLE AII. 108

Diet	Number of items, n	Sum, Σx	Mean, x̄
Starvation (N)	16	1452	90.8
Positive Control (P)	16	1716	107.2
CHO, 1000 Cal. (A-1)	8	747	93.4
CHO, 2000 Cal. (A-2)	8	699	87.4
Meat Bar, 1000 Cal. (B-1)	4	606	151.5
Meat Bar, 2000 Cal. (B-2)	4	682	170.5
Chocolate Bar, 1000 Cal. (C-1)	4	441	110.2
Chocolate Bar, 2000 Cal. (C-2)	4	392	98.0
Meat and Cereal, 1000 Cal. (D-1)	8	1063	132.5
Meat and Cereal, 2000 Cal. (D-2)	8	769	96.1
Total	80	8564	107.0

STAT

TABLE AII. 109 (contd)

Diet	Number of items, n	Sum, SX	Mean, $\bar{X}$
Caloric Levels			
0 Cal.	16	1452	90.8
1000 Cal.	24	2854	118.9
2000 Cal.	24	2542	105.9
3000 Cal.	16	1716	107.2
Types of Diet			
A	16	1446	90.4
B	8	1288	161.0
C	8	833	104.1
D	16	1829	114.3

TABLE AII. 110

ANALYSIS OF VARIANCE OF TABLE AII. 108

Source of Variation	d.f.	S.S.	M.S.	F
Caloric levels (C)	3	7662	2554	6.32**
Diets (D)	3	27264	9088	22.50**
Interaction (CXD)	3	4430	1477	3.66**
Individuals on same diet	30	12116	404	
Difference between weeks	40	12002	300	
Total	79	63474		

** Significant at the 1% level.

For individual comparisons, for example D-1 with D-2, the F-test may be followed by a t-test as follows: For two groups of 8 items each, the standard error of the difference between means is

$$s_{\bar{d}} = \sqrt{\frac{2s^2}{n}} = \sqrt{\frac{2(404)}{8}} = \sqrt{101} = 10.05$$

Then the t value is

$$t = \frac{(D\text{-}1) - (D\text{-}2)}{s_{\bar{d}}} = \frac{36.4}{10.05} = 3.62**$$

TABLE AII. 111

PRE-PERIOD CHOLESTEROL (TOTAL) AS PERCENTAGE OF AVERAGE

Phase	1	2	3	4-12	5	6	7	8	C	100/C
1	84	79	104	107	87	94	95	79	91	1.14
	100	96	96	93	72	80	81	73	86	88
2	82	55	73	84	120	102	103	111	91	1.10
3	131	134	127	122	112	107	136	131	121	.83
4	127	131	113	105	116	111	106	111	115	.87
5	75	105	86	89	93	107	109	95	95	1.05

(The cyclical index C is the average of the percentages in average for the 3 individuals for a particular phase.)

TABLE AII. 112

EXPERIMENTAL CHOLESTEROL (TOTAL) AS PERCENTAGE OF CYCLICAL NORMAL

STARVATION

1	2	3	12	5	6	7	8
115	106	89	139	106	80	111	79
124	106	78	122	96	80	90	104
239	212	167	261	202	160	201	183

POSITIVE CONTROL

1	2	-3	12	5	6	7	8
99	115	114	120	103	98	93	103
97	111	94	92	98	93	98	95
196	226	208	212	201	191	191	198

CHO (1000 Cal.)				CHO (2000 Cal.)			
5	6	7	8	1	2	3	12
119	98	95	69	96	112	112	81
98	98	73	87	86	93	90	63
217	196	168	156	182	205	202	144

STAT
STAT

TABLE AII. 112 (contd)

MEAT BAR (1000 Cal.)		MEAT BAR (2000 Cal.)		CHOCOLATE BAR (1000 Cal.)		CHOCOLATE BAR (2000 Cal.)	
		1	2	5	6	3	12
7	8	139	149	90	99	75	109
162	168	131	146	96	81	71	85
140	197	270	295	186	180	146	195
302	365						

MEAT BAR AND CEREAL BISCUIT (1000 Cal.)				MEAT BAR AND CEREAL BISCUIT (2000 Cal.)			
1	2	5	6	3	4	7	8
120	125	121	120	111	115	86	107
120	126	103	87	78	105	114	124
240	251	224	207	189	220	200	231

TABLE AII. 113

SUMMARY OF DATA OF TABLE AII. 112

Diet	Number of items, n	Sum, ΣX	Mean, $\bar{X}$
Starvation (N)	16	1625	101.6
Positive Control (P)	16	1623	101.4
CHO, 1000 Cal. (A-1)	8	737	92.1
CHO, 2000 Cal. (A-2)	8	733	91.6
Meat Bar, 1000 Cal. (B-1)	4	667	166.8
Meat Bar, 2000 Cal. (B-2)	4	565	141.2
Chocolate Bar, 1000 Cal. (C-1)	4	366	91.5
Chocolate Bar, 2000 Cal. (C-2)	4	341	85.2
Meat and Cereal, 1000 Cal. (D-1)	8	922	115.2
Meat and Cereal, 2000 Cal. (D-2)	8	840	105.0
Caloric levels			
0 Cal.	16	1625	101.6
1000 Cal.	24	2692	112.2
2000 Cal.	24	2479	103.3
3000 Cal.	16	1623	101.4
Types of Diet			
A	16	1470	91.9
B	8	1232	154.0
C	8	707	88.4
D	16	1762	110.1

TABLE AII. 114

ANALYSIS OF VARIANCE FOR DATA OF TABLE AII. 112

Source of Variation	d.f.	S.S.	M.S.	F
Caloric levels (C)	3	1690	563	1.72
Diets (D)	3	24238	8079	24.71**
Interaction (CXD)	3	855	285	0.87
Individuals on same diet	30	0415	327	2.27**
Difference between meals	40	5749	144	
Total	79	42348		

A pairwise comparison of diets is made by the following t-tests:

Comparison	Observed Difference	Standard Error	t
B - D	43.9	7.83	5.61**
B - A	62.1	7.83	7.93**
B - C	65.6	9.04	7.26**
D - A	18.2	6.39	2.85**
D - C	21.7	7.83	2.77**
A - C	3.5	7.83	0.45

D. CREATININE CLEARANCE

In planning for the field trials, the importance of a critical evaluation of renal function has been demonstrated by the data in this report. A protocol for conducting renal function tests depends upon careful control of the several variables which might prejudice the results. The most serious variable influencing the results is the dietary intake of protein. According to Smith et al. (1951), if the protein intake is less than 40 gm/day excellent data can be obtained from non-fasting subjects. When the diet provides more than 40 gm/day of protein, the subject should be on a low protein diet for 48 hours prior to conducting the creatinine clearance test. This ideal arrangement would be impossible to realize under the conditions of the field trials, for the dietary intake of protein will be fixed at levels greater than 40 gm/day in many of the subjects.

During the researches of 1952-53, data were collected with a view to providing a solution to this problem. Once a week each man was given a two-hour test in which a timed urinary specimen was collected and a blood sample was drawn. The subjects were not fasting. The blood and urine were analyzed for creatinine. On the next day a twenty-four urinary specimen was collected and this urine was also analyzed for creatinine. The minute volume of serum cleared of creatinine was calculated using the relation C (ml/min) = U (mg/ml) x V (ml/min) / S (mg/ml), where C is the clearance, U, urinary creatinine, V, minute urinary volume, and S, serum creatinine. An analysis of the data is given in Table AII. 115. Three experimental conditions were given special attention. (1) When all the data were treated regardless of the experimental conditions, the correlation coefficient (value not legible) of a scatter-diagram of these 146 points

revealed that in 14 instances, the correlation between the two clearances was poor. Nine points were accounted for by two subjects and 13 of the points fell in the pre-period or recovery period when the protein intake was high. In general, the two-hour test, in these instances was twice as high as the 24-hour test. Post-chat changes in serum or urinary creatinine caused by the high intake of protein may have caused these poor correlations. (2) When only data collected at a time when the subjects were on diets providing less than 40 gm. of protein per day were used, the correlation coefficient rose to 0.824. The intercept of the regression equation was close to zero. (X = 0, Y' = 7.6). (3) An even better correlation was achieved in a special 72-hour fasting-thirsting experiment on two alternate subjects. The coefficient of correlation was 0.920 and the intercept was hardly different from zero (X = 0, Y' = 1.4). Thus, when the protein intake is less than 40 gm/day, the two-hour test will yield reliable clearance values on the non-fasting subject.

TABLE AII. 115

CORRELATION BETWEEN TWO-HOUR AND 24-HOUR CREATININE CLEARANCE

Experimental Conditions	N	Regression Equation*	r
(1) All data	146	Y' = 49.5201 + 0.6528 X	0.621
(2) Protein intake 40 gm/day	39	Y' = 7.6037 + 0.9180 X	0.824
(3) Fasting-thirsting	22	Y' = 1.4159 + 0.9733 X	0.920

* Y' = Clearance from two-hour urine; X = Clearance from 24-hour urine.

APPENDIX III

DIGESTS: TABLE OF CONTENTS

STAT
STAT

TABLE AIII. 1

DIET ANALYSIS SUMMARY SHEET, DAILY AVERAGES, ALL PERIODS

Subject No. 1

Period	Vol	Water in Food	Mat Water	Cal	CHO	CHO	Fat	Fat	PRO	PRO	PRO N	Ca	P	Cl
	ml	gm	gm		gm	%Cal	gm	%Cal	gm	%Cal	gm	mg	mg	mg
1/6-1/11	1587	906	444	3331	409	49	138	37	124	15	19.8	630	1448	13073
1/12-1/18	1851	983	425	3184	402	50	122	34	130	16	20.8	830	1547	13129
1/19-1/25	493	422	392	3072	354	47	128	38	103	14	16.4	420	1119	10854
1/26-2/1	460	436	391	3008	304	40	153	46	110	15	17.6	526	1268	11694
2/2-2/8	2338	849	397	2951	400	54	110	33	95	13	15.3	1010	1313	9915
2/9-2/15	2027	994	366	2716	343	50	109	36	106	15	17.0	627	1364	11226
2/16-2/22	1307	-	-	-	-	-	-	-	-	-	-	69	-	8
2/23-2/26	1375	-	-	-	-	-	-	-	-	-	-	73	-	8
2/27-3/1	2319	949	440	3676	563	61	105	26	122	13	19.5	1063	1545	12027
3/2-3/8	2061	1075	617	4621	570	49	200	39	149	13	23.9	1660	2265	13499
2 days	2645	1366	648	4868	578	47	216	37	170	14	27.1	1498	2174	18828
3/11-3/15	2354	1217	563	4212	588	57	143	31	110	14	22.4	1112	1810	13827
3/16-3/20	880	20	223	1993	-	-	151	68	149	30	23.8	110	1188	71
3/30-4/5	2468	981	581	4319	553	51	177	37	145	13	23.2	1558	2124	13232
4/6-4/12	2632	1111	498	3735	477	51	137	33	160	17	25.6	1069	1853	16574
4/13-4/19	1901	14	133	998	129	52	38	34	36	14	5.8	276	657	139
4/20-4/26	2079	156	133	977	126	52	38	34	37	15	5.9	272	675	365
4/27-5/3	2453	1271	648	4963	625	50	208	38	172	14	27.5	1589	2302	13440
5/4-5/10	2085	1326	566	4163	577	55	148	32	151	14	24.2	1665	1469	15921
5/11-5/17	875	30	300	1979	501	100	-	-	-	-	-	46	3	45
5/18-5/24	742	154	304	1997	506	100	-	-	-	-	0	.2	52	32	199
5/25-5/31	2512	977	594	4431	553	50	189	38	147	13	23.5	1590	1985	11398

TABLE AIII. 2

DIET ANALYSIS SUMMARY SHEET, DAILY AVERAGES, ALL PERIODS

Subject No. 2

Period	Vol	Water in Food	Mat Water	Cal	CHO	CHO	Fat	Fat	PRO	PRO	PRO N	Ca	P	Cl
	ml	gm	gm		gm	%Cal	gm	%Cal	gm	%Cal	gm	mg	mg	mg
1/6-1/11	1153	801	420	3092	421	54	116	34	106	14	17.0	603	1406	12074
1/12-1/18	1338	876	415	3080	403	52	114	34	114	15	18.2	776	1429	12265
1/19-1/25	1559	415	395	2989	365	49	125	38	110	15	17.6	826	1311	12819
1/26-2/1	1797	437	393	2984	337	44	139	42	110	15	17.6	867	1248	223 5
2/2-2/8	1958	761	454	3376	424	49	154	41	99	12	15.8	1.5	1236	11113
2/9-2/15	1643	851	356	2905	392	54	110	34	106	14	17.0	593	1139	12010
2/16-2/22	900	-	-	-	-	-	-	-	-	-	-	-	-	5
2/23-3/1	900	-	-	-	-	-	-	-	-	-	-	-	-	5
3/2-3/8	2213	911	625	4339	646	58	161	31	154	14	25.4	2116	2462	12217
3/9-3/10	1734	992	642	4832	572	48	215	40	148	12	27.0	1689	2438	13535
3/11-3/15	1471	905	530	3838	520	53	155	36	124	13	20.3	1519	1841	195.8
3/16-3/22	1632	20	223	1993	-	-	151	68	149	30	23.8	110	1188	76
3/23-3/29	1746	20	223	1993	-	-	151	68	149	30	23.8	155	1189	76
3/30-4/5	1685	776	651	4659	563	46	235	43	150	12	24.0	1740	2442	12358
4/6-4/12	1233	947	566	4154	535	56	150	32	132	13	21.1	1[illegible]	2227	13938
4/13-4/19	872	14	133	976	129	52	38	34	36	14	5.8	255	658	203
4/20-4/26	394	21	133	978	130	52	38	34	36	14	5.8	269	662	2.8
4/27-5/3	1489	858	657	4879	616	50	215	40	159	11	22.2	1624	2248	11.11
5/4-5/10	1379	831	525	3951	533	56	148	33	125	13	20.0	827	1675	12757
5/11-5/17	1493	31	304	1995	506	100	-	-	-	-	-	79	-	14
5/18-5/22	2386	32	304	1996	506	100	-	-	-	-	-	124	-	14
5/23-5/24	1705	606	505	3799	479	50	154	36	131	14	21.0	1291	2027	9114
5/25-5/31	1544	724	518	3835	453	47	132	32	127	13	20.3	1763	2080	9013

STAT
STAT

TABLE AIII. 3

DIET ANALYSIS SUMMARY SHEET, DAILY AVERAGES, ALL PERIODS

Subject No. 3

Period	Vol	Water in Food	Wat Water	Cal	CHO	CHO	Fat	Fat	PRO	PRO	PRO	Ca	P	Cl
	ml	gm	gm		gm	%Cal	gm	%Cal	gm	%Cal	gm	mg	mg	mg
1/6-1/11	1738	852	432	3188	430	54	120	34	114	14	18.2	729	1462	11552
1/12-1/18	1822	893	441	3253	444	55	118	33	118	14	18.5	577	1334	12704
1/19-1/25	867	424	257	1869	238	50	78	37	75	16	12.0	366	1373	2382
1/26-1/27	1252	180	249	1840	258	56	64	31	62	14	13.0	362	1134	2056
1/28-2/1	1652	711	404	3639	370	49	130	38	105	14	16.8	632	1124	10182
2/2-2/8	1606	727	408	3086	378	50	138	41	82	11	13.1	617	1081	9564
2/9-2/15	1657	1003	380	2807	377	54	103	33	106	15	17.0	466	1159	11703
2/16-2/22	1567	-	-	-	-	-	-	-	-	-	-	83	-	9
2/23-2/24	950	-	-	-	-	-	-	-	-	-	-	50	-	6
2/25-3/1	1755	764	356	2515	364	56	95	33	87	13	14.0	653	1094	8014
3/2-3/8	1482	976	478	3586	402	45	173	45	114	13	16.3	959	1558	11195
3/9-3/15	980	1167	417	3083	412	53	116	34	112	14	17.8	537	1294	12750
3/16-3/22	444	457	400	2991	362	48	131	39	103	14	16.4	403	1113	9216
3/23-3/29	462	450	395	2984	356	48	134	40	103	14	16.5	487	2320	8601
3/30-3/31	1335	559	546	4118	376	36	257	56	111	11	17.8	1381	1938	9576
4/6-4/12	1370	960	446	3344	360	43	168	45	123	15	19.7	553	1447	11116
4/13-4/19	1342	30	246	1960	97	20	177	80	7	1	1.0	104	245	2514
4/20-4/26	1183	32	188	1484	81	22	127	76	12	3	1.9	114	272	3834
4/27-5/3	1210	934	512	3833	377	39	224	53	112	12	17.9	890	1677	8141
5/4-5/10	1220	814	403	2994	352	47	150	45	88	12	14.2	567	1519	8063
5/11-5/17	850	31	304	2000	506	100	-	-	-	-	-	45	5	71
5/18-5/24	475	248	268	1739	445	100	-	-	2	-	.3	70	52	173
5/25-5/31	2571	1140	624	4708	449	38	219	53	138	12	22.1	1736	2363	9065

460

TABLE AIII. 4

DIET ANALYSIS SUMMARY SHEET, DAILY AVERAGES, ALL PERIODS

Subject No. 12

Period	Vol	Water in Food	Wat Water	Cal	CHO	CHO	Fat	Fat	PRO	PRO	PRO	Ca	P	Cl
	ml	gm	gm		gm	%Cal	gm	%Cal	gm	%Cal	gm	mg	mg	mg
2/3-2/8	2022	984	448	3270	465	56	112	31	123	15	19.6	859	1641	13755
2/9-2/15	1.58	932	446	3158	416	52	137	39	122	15	19.6	728	1557	13797
2/16-2/22	836	-	-	-	-	-	-	-	-	-	-	44	-	5
2/23-2/24	850	-	-	-	-	-	-	-	-	-	-	45	-	5
2/25-3/1	2396	1087	555	4059	569	56	150	33	130	13	20.8	1118	1633	12146
3/2-3/8	1643	238	622	4686	534	46	222	43	115	13	24.8	1240	2111	15033
3/9-3/15	1829	942	526	3915	497	49	163	38	114	15	23.2	889	1102	17616
3/16-3/22	1637	481	402	3025	380	48	132	39	110	14	17.6	521	1179	10664
3/23-3/29	1.77	493	395	2954	350	47	130	39	113	15	18.0	528	1173	10728
3/30-4/5	1526	1218	466	3702	405	44	176	43	139	15	22.3	1168	1846	13803
4/6-4/12	1562	903	428	3247	370	47	143	40	130	16	20.8	730	1755	16578
4/13-4/19	800	45	221	1748	84	19	155	80	12	3	1.9	84	325	4563
4/20-4/21	877	23	126	1000	46	18	69	60	8	3	1.3	65	73	2381
4/22-4/26	2424	1028	390	7795	466	70	50	16	109	16	17.5	933	1443	9671
4/27-5/3	1466	838	482	3145	400	51	129	37	103	1.	17.3	884	1363	9542
5/4-5/10	1398	1024	409	3115	336	43	146	42	125	16	20.0	854	1538	13180
5/11-5/17	124.	25	307	2002	512	100	-	-	-	-	-	66	2	20
5/18-5/24	975	669	316	1939	520	100	2	1	5	1	.8	169	128	587
5/25-5/31	3190	780	544	4149	401	39	221	48	152	15	24.4	1437	1984	13947

461

STAT
STAT

TABLE AIII. 5

DIET ANALYSIS SUMMARY SHEET, DAILY AVERAGES, ALL PERIODS

Subject No. 4

Period	Vol. ml	Water in Food gm	Met Water gm	Cal	CHO gm	CHO %Cal	Fat gm	Fat %Cal	PRO gm	PRO %Cal	PRO N gm	Ca mg	P mg	Cl mg
1/6-1/11	1431	839	403	3060	343	45	136	40	125	16	20.0	704	1309	12499
1/12-1/18	1292	914	413	3106	368	47	131	38	126	16	20.2	789	1539	12877
1/19-1/25	1626	87	233	1777	200	45	78	40	73	16	11.7	319	1340	1212
1/26-2/1	1446	487	271	1976	262	53	76	36	74	15	11.8	466	1373	911
2/2-2/8	1615	906	483	3650	415	45	168	41	133	14	21.3	865	1581	13744

TABLE AIII. 6

DIET ANALYSIS SUMMARY SHEET, DAILY AVERAGES, ALL PERIODS

Subject No. 5

Period	Vol ml	Water in Food gm	Met Water gm	Cal	CHO gm	CHO %Cal	Fat gm	Fat %Cal	PRO gm	PRO %Cal	PRO N gm	Ca mg	P mg	Cl mg
1/20-1/25	1693	825	388	2982	317	42	135	41	129	17	20.7	499	1292	12570
1/26-2/1	1693	671	429	3237	387	48	136	38	126	15	20.2	526	1308	13610
2/2-2/8	1136	-	-	-	-	-	-	-	-	-	-	62	-	7
2/9-2/15	2012	861	480	3628	420	46	169	42	115	13	18.4	1066	1244	11577
2/16-2/22	1360	850	554	42[illegible]	468	44	206	44	129	12	20.7	1215	1542	12709
2/23-3/1	1569	873	371	2772	365	53	98	32	115	17	18.5	493	1151	13038
3/2-3/6	869	14	151	970	251	100	-	-	-	-	-	46	1	21
3/9-3/13	862	33	152	1038	256	100	-	-	-	-	-	57	14	819
3/14-3/15	1339	1060	360	2904	325	44	124	38	128	17	20.5	1073	1530	11485
3/16-3/22	1246	995	530	4435	530	48	192	37	163	15	25.0	1519	2141	13856
3/23-3/29	1355	973	374	2789	360	52	104	34	114	16	18.3	665	1253	12593
3/30-4/5	1136	9	129	945	52	21	92	82	-	-	-	60	84	7
4/6-4/12	1232	19	127	1005	50	20	39	80	5	2	.9	91	138	1947
4/13-4/19	1925	937	657	4941	594	48	224	42	149	12	23.9	1816	2669	13941
4/20-4/26	1646	946	474	3529	443	50	147	37	126	14	20.2	1014	1695	13020
4/27-5/3	809	91	133	968	130	52	38	34	36	14	5.8	781	668	300
5/4-5/6	783	117	134	1001	131	52	38	34	36	14	5.8	190	671	320
5/7-5/10	1495	836	558	4170	512	49	182	39	137	13	21.9	1437	1796	12477
5/11-5/17	1525	962	622	4661	548	47	221	43	139	12	22.2	1217	2089	12762
5/18-5/24	1762	945	411	3091	392	51	123	36	116	15	18.6	737	1334	12252
5/25-5/31	2194	670	394	2972	346	47	132	40	110	15	17.7	456	1173	10722
6/1-6/7	1694	810	400	3003	357	48	131	39	112	15	17.9	496	1258	10441
6/8-6/12	2797	1310	452	3358	404	48	156	42	105	12	16.8	1012	1317	8396

TABLE AIII. 7

DIET ANALYSIS SUMMARY SHEET, DAILY AVERAGES, ALL PERIODS

Subject No. 6

Period	Vol	Water in Food	Met Water	Cal	CHO	CHO	Fat	Fat	PRO	PRO	PRO N	Ca	P	Cl
	ml	gm	gm		gm	%Cal	gm	%Cal	gm	%Cal	gm	mg	mg	mg
1/19-1/25	1186	827	364	2801	296	42	126	40	126	18	20.1	650	3351	12214
1/26-2/1	1521	882	413	3155	362	46	133	38	131	17	21.0	618	1438	13869
2/2-2/8	769	-	-	-	-	-	-	-	-	-	-	41	-	5
2/9-2/10	900	-	-	-	-	-	-	-	-	-	-	48	-	5
2/11-2/15	2339	748	476	3563	440	49	151	38	123	14	19.7	1137	1570	11477
2/16-2/22	1630	xxx	589	4620	600	49	208	38	157	13	25.1	1557	2136	13917
2/23-3/1	1331	858	371	3409	460	54	123	33	132	15	21.2	700	1446	11545
3/2-3/8	966	18	152	1009	254	100	-	-	-	-	-	52	-	8
3/9-3/13	1000	17	152	998	253	100	-	-	-	-	-	54	-	8
3/14-3/15	2237	953	372	3624	454	50	136	34	170	19	27.2	1877	2252	11819
3/16-3/22	1954	1012	596	4113	551	51	189	38	155	14	24.9	1598	2251	13641
3/23-3/29	1316	1077	507	3789	485	51	146	35	116	15	23.4	946	1613	14874
3/30-4/5	891	9	189	999	52	21	91	82	-	-	-	47	84	5
4/6-4/12	890	18	129	1066	51	20	90	80	5	2	.7	65	134	1703
4/13-4/19	2091	1133	714	5374	628	47	240	40	196	15	31.3	2472	3202	13796
4/20-4/26	1030	1132	639	4742	569	48	217	41	159	13	25.5	1099	2170	14735
4/27-5/3	1206	238	136	1001	133	53	38	34	38	15	6.1	275	692	512
5/4-5/6	1130	141	135	1000	132	53	38	34	36	14	5.8	233	173	431
5/7-5/10	2444	770	544	4058	479	47	184	41	146	15	23.4	1939	2475	9983
5/11-5/17	1669	807	601	4512	476	42	232	46	163	14	26.0	1810	2548	11204
5/18-5/24	1336	881	373	2804	320	46	127	41	109	16	17.5	803	1431	10984
5/25-5/31	597	391	393	2963	326	44	143	43	108	14	17.2	513	1296	9402
6/1-6/7	2324	918	331	3000	343	46	134	40	124	16	19.8	713	1577	10955
6/8-6/12	2004	606	345	2507	328	52	107	38	83	13	13.3	993	1288	5854

TABLE AIII. 8

DIET ANALYSIS SUMMARY SHEET, DAILY AVERAGES, ALL PERIODS

Subject No. 7

Period	Vol	Water in Food	Met Water	Cal	CHO	CHO	Fat	Fat	PRO	PRO	PRO N	Ca	P	Cl
	ml	gm	gm		gm	%Cal	gm	%Cal	gm	%Cal	gm	mg	mg	mg
1/19-1/25	2276	820	279	2877	324	45	129	40	124	16	18.2	494	1167	11904
1/26-2/1	2248	832	442	3331	402	48	140	38	124	15	19.9	510	1295	13927
2/2-2/6	1733	-	-	-	-	-	-	-	-	-	-	92	-	10
2/9-2/11	2033	-	-	-	-	-	-	-	-	-	-	113	-	13
2/12-2/15	2316	847	482	3602	454	50	145	36	134	15	21.5	833	1425	12919
2/16-2/22	3727	1161	729	5331	655	49	214	42	149	12	23.4	1268	1955	14310
2/23-3/1	2430	1072	569	4023	559	52	161	34	141	15	22.8	753	1728	17269
3/2-3/8	830	10	111	997	-	-	75	68	75	30	12.0	75	594	38
3/9-3/15	778	121	268	2000	262	52	76	34	42	14	11.4	146	662	4039
3/16-3/22	4039	1249	778	5846	705	47	260	42	183	12	29.3	2041	2514	15559
3/23-3/29	2830	1095	682	4923	664	54	183	34	170	14	27.3	1355	2064	17687
3/30-4/5	3053	478	404	3059	376	49	128	38	100	13	16.0	620	1450	11103
4/6-4/12	3013	482	326	3005	341	45	133	41	104	14	16.7	556	1152	10714
4/13-4/19	3267	1057	771	5759	691	48	250	41	195	13	30.3	1950	2832	13732
4/20-4/26	2702	1040	567	4825	575	47	224	40	174	14	27.8	1143	2261	15781
4/27-5/3	883	17	152	998	253	100	-	-	-	-	-	47	2	34
5/4-5/10	583	17	152	998	253	100	-	-	-	-	-	47	2	34
5/11-5/17	3057	816	606	4496	524	46	221	44	150	13	24.0	1372	2047	12490
5/18-5/24	2480	1263	533	3990	478	48	172	39	152	15	24.3	1276	2061	15518
5/25-5/31	2976	612	276	2018	268	53	78	35	78	15	12.5	440	1455	2202
6/1-6/7	3200	405	271	2096	270	54	75	34	71	14	11.4	304	729	4302

TABLE XIII. 9

DIET ANALYSIS SUMMARY SHEET, DAILY AVERAGES, ALL PERIODS

Subject 8

Period	Vol	Water In Food	Wat Water	Cal	CHO	Fat	Fat	PRO	PRO	Ca	P	Ci
	ml	gm	gm		gm	gm	%Cal	gm	%Cal	mg	mg	mg
1/19-1/25	1662	823	380	2895	321	130	40	118	16	454	1199	12901
1/26-2/1	1578	830	381	2882	336	124	39	114	16	458	1139	12654
2/2-2/8	884	-	-	-	-	-	-	-	-	47	-	5
2/9	900	-	-	-	-	-	-	-	-	48	-	5
2/10-2/15	2558	926	593	4332	541	189	39	140	13	1098	1509	13937
2/16-2/22	2207	975	646	4820	557	225	42	159	13	1163	1972	23712
2/23-3/1	2620	981	596	3777	491	114	34	140	15	847	1498	15251
3/2-3/8	2257	10	110	918	-	-	07	-	30	151	595	47
3/9-3/15	2579	10	111	999	-	-	68	-	30	238	595	47
3/16-3/22	2256	1190	783	5811	729	255	40	178	12	1266	2444	15339
3/23-3/29	1825	1124	684	4864	687	176	32	156	13	959	1751	16392
3/30-4/5	465	462	402	3058	382	135	40	114	15	430	1191	11069
4/6-4/12	478	408	397	2999	347	135	40	108	15	399	1113	11355
4/13-4/19	2186	804	496	3716	453	161	34	120	13	1174	1681	9982
4/20-4/26	1920	813	427	3183	431	118	34	103	13	718	1320	15026
4/27-5/3	1578	17	151	992	251	-	-	-	-	84	2	39
5/4-5/10	1590	14	151	990	251	-	-	-	-	84	2	39
5/11-5/17	2238	797	507	3809	439	145	41	186	13	1097	1598	10540
5/18-5/24	1808	676	383	2847	369	240	52	111	15	654	1189	11033
5/25-5/31	1007	59	253	1881	240	74	35	104	15	277	1233	1029
6/1-6/7	1990	378	268	1972	255	76	36	76	15	313	1409	2222
6/8-6/12	2627	543	306	2280	276	101	40	79	14	714	1993	5443

B. Standard Procedures

Orange Juice Dilution.

200 gm frozen concentrate
550 gm water
750 gm reconstituted juice

Starlac Dilution.

100 gm Starlac
900 gm water
1000 gm reconstituted milk

Bacon (sample only): each plate. Isolated separately.

100 gm (all 3 portions) bacon before cooking
350 gm fat rendered by cooking
100 gm (-45 gm) recorded

For analysis the figures for 100-gram portions were used in cases of water, carbohydrate, protein, ash and gals. The figure for fat was the difference between the analysis figure and 45 gm, and calories the difference between the analysis figure and 45 gm x 9 Cal/gm.

Example:

	=	Water	Cal	CHO	Fat	PRO	Ca
100 gm	=	7	523	1	54	9	15
100 gm (-45)	=	7	118	1	9	9	15

C. Recipes: Pre-Period and Recovery Period

Horse Radish Sauce (approx. 1 gal.).

3360 gm catsup
15 gm dehydrated horse radish
50 gm water
222 gm vinegar
7 gm tabasco
33 gm Worcestershire sauce

Tomato Fish Sauce (approx. 1 gal.).

3450 gm catsup
268 gm fish sauce
226 gm vinegar, distilled white.
20 gm tabasco

Soups (Tomato, Chicken, Bouillon).

Equal amounts of concentrated soup and water.

Chocolate Syrup.

For a syrup suitable for ice cream sauce or chocolate milk that could be kept in the refrigerator, equal weights of cocoa beverage powder and water were mixed.

Peanut Butter.

75 gm ground peanuts
25 gm melted margarine
100 gm peanut butter

Beef Barbecue.

1. 1 can beef and gravy (950 gm)
   1 can tomato soup (220 gm)
   1 can catsup (100 gm)

2. 1 can beef and gravy (950 gm)
   1/2 can tomatoes (250 gm)
   1 can catsup (100 gm)

3. 2 cans hamburgers (900 gm)
   1 can tomato soup (200 gm)
   1 can catsup (100 gm)

In each combination the liquid with the meat was mixed with the tomatoes or tomato soup, and boiled until thick. The meat and catsup were added and the mixture heated.

Beef and Vegetable Soup.

1 can each vegetable (corn, beans, peas, limas, tomatoes)
1 can beef and gravy or roast beef, or
2 cans hamburgers, cut up in small pieces
500 gm water (more or less, depending on mixture desired)

These foods mixed and heated in double boiler, over low heat for 1 hr.

Beef Loaf.

2 cans hamburgers (900 gm)
1 can catsup (100 gm)
4 crackers (5-in-1) (100 gm)

The hamburger gravy was boiled down to about 1/2 its original volume. The hamburger was ground up and mixed with the cracker crumbs, catsup and

gravy. The loaf was baked in small individual servings, sometimes with additional catsup spread over the top.

Ham and Peas, Creamed.

1 can ham chunks (950 gm)
1 can peas (550 gm)
cornstarch (20 gm)
Starlac, dry (20 gm)

The pea liquid was used to dissolve the cornstarch and Starlac, and added to the ham and peas. This was heated in a double boiler until thickened.

Ham Patties or Ham Loaf.

1 can pork loaf ("Spam") (320 gm)
2 crackers (5-in-1) (45 gm)

The pork loaf and crackers were put through the food chopper and mixed well. These were made into 90-gram patties and broiled or fried until brown. The loaf was made by packing 200 gm into an individual casserole, with catsup spread on top. The loaf was baked about 45 min in a slow oven.

Ham and Cheese Spread.

Equal weights of ground pork loaf mixed with the cheese spread. This combination was used as a regular sandwich filling or was spread on toast and placed under the broiler for a few minutes.

Meat Balls and Spaghetti with Cheese.

Individual casseroles were filled with the spaghetti mixture (usually 250 gm) then 40-50 gm of the cheese spread were put on top. These were baked 30-45 min in a slow oven.

Vienna Sausage, Cheese and Bacon.

The vienna sausages were split down the middle, cheese spread put in the split, and cooked bacon put on top. These were broiled 3-5 min. (For the study, the sausages were all cut to equal weight, 30 gm, with 10 gm of cheese spread, and 10 gm of crisp bacon. The bacon was prepared in the same manner as the breakfast bacon.)

White Potatoes or Sweet Potatoes, Mashed.

The whole can was boiled until there was about 100 gm of liquid left. The potatoes and remaining juice were mashed together.

White Potatoes, Creamed.

1 can potatoes (400 gm)

Starlac (10 gm)
flour (10 gm)

The potato water was used to dissolve the Starlac and flour, and put into a double boiler with diced potatoes to thicken.

White Potatoes, Escalloped.

Sliced potatoes with proportionate amounts of juice equivalent were put into individual casseroles (about 150 gm) and 50 gm of cheese spread added in small pieces. This was baked about 30-45 min in a slow oven.

Cream of Corn Soup.

1 can corn (350 gm)
Starlac (100 gm)
water (400 gm)

Succotash.

Equal weights lima beans and corn mixed.

Lima Beans with Tomato Sauce.

1 can lima beans (550 gm)
1 can tomato soup (250 gm)

The vegetable juice and soup were boiled together until thick, then the beans added.

Tomato-Cheese Sandwich.

A can of tomatoes was boiled down until thick. This was spread over toast, pieces of cheese spread added, and placed under a broiler until the cheese melted.

Chocolate Pudding.

100 gm cocoa-beverage powder
100 gm Starlac
30 gm cornstarch
30 gm sugar
450 gm water

This was mixed and cooked in a double boiler until thick.

Chocolate Cream Pie.

Chocolate pudding in pie shell made with
200 gm flour
100 gm margarine
50 gm water

Orange-Pineapple Sherbet.

1 can pineapple, juices (800 gm)
2 cans powdered milk (5-in-1) (150 gm)
frozen orange juice concentrate (100 gm)
sugar (100 gm)

This mixture was frozen in icebox.

D. Recipes: Experimental Periods

	H_2O	Cal.	CHO
	ml		gm
0/100/0 1000.			
Starch Jelly Bar, 112 gm	11	400	100
Hard Candy, 60 gm	1	230	59
Spice Drops, 100 gm	7	369	93
	19	999	252
0/100/0 2000.			
Hard Candy, 169 gm	2	648	167
Spice Drops, 313 gm	20	1155	291
Sugar, 11 gm	—	42	11
Gum, 44 gm	—	154	40
	22	1999	509

	H_2O	Cal	CHO	Fat	PRO
	ml		gm	gm	gm
30/0/70 1000.					
Meat Bar, 165 gm (3 meals, 55 gm each)	10	997	-	75	75
30/0/70 2000.					
Meat Bar 331 gm (3 meals, 110 gm each)	20	1999	-	151	150
2/20/78 1000.					
(1) Exp. Chocolate Bar, 152 gm (wrapper = 0.4 gm)	9	1001	52	91	-
(2) Exp. Chocolate Bar, 75 gm	5	493	26	45	-
Oleo, 50 gm	9	360	-	40	.3
Saltines, 36 gm	3	153	25	4	3.6
	17	1006	51	89	4.0

	H_2O ml	Cal	CHO gm	Fat gm	PRO gm
(3) Exp. Chocolate Bar, 50 gm	3	349	17	30	-
Oleo, 66 gm	12	475	-	53	-
Saltines, 48 gm	4	204	34	6	5
	19	1028	51	89	5
(4) Exp. Chocolate Bar, 30 gm	2	156	10	18	-
Oleo, 80 gm	14	576	-	65	5
Saltines, 54 gm	4	230	38	7	5.4
	20	1062	48	90	5.9

	H_2O ml	Cal	CHO gm	Fat gm	PRO gm	Ca mg
(5) Oleo, 100 gm	18	720	.4	81.0	.6	20
Saltines, 66 gm	5	280	46.2	8.2	6.6	16
	23	1000	46.6	89.2	7.2	36

2/20/78 2000.

(1) Exp. Chocolate Bar, 305 gm	18	2004	104	183	-	
(2) Exp. Chocolate Bar, 152 gm	9	1001	52	91	-	-
(152 gm with wrapper)	18	720	-	81	.6	17
Oleo, 100 gm	5	280	46	8	6.6	16
Saltines, 66 gm	32	2001	98	180	7.2	32
(3) Exp. Chocolate Bar, 75 gm	5	473	26	45	-	
Oleo, 150 gm	28	1030	1	122	1	
Saltines, 100 gm	8	425	70	12	10	
	41	1928	97	179	11	
(4) Oleo, 200 gm	36	1440	.8	162.0	1.2	40
Saltines, 133 gm	11	565	93.1	16.6	13.3	33
	47	2005	93.9	178.6	14.5	73

15/52/33 1980.

Meat Bar, 60 gm	4	362	-	27	27
Cereal Bar, 90 gm	9	364	59	11	9
Starch Jelly, 56 gm	6	200	50	-	-
Spice Drops, 20 gm	1	74	19	-	-
	20	1000	128	38	36

15/52/33 2000.

(1)* Meat Bar, 120 gm	7	725	-	55	54
Cereal, 100 gm	18	729	118	23	18
Jelly Bar, 112 gm	11	460	100	-	-
Spice Drops, 40 gm	3	148	37	-	-
	39	2002	255	78	72

472

	H_2O ml	Cal	CHO gm	Fat gm	PRO gm	Ca mg
(2) Meat Bar, 120 gm	7	725	-	55	54	
Crackers, 137 gm	6	614	91	21	12	
Sauce, 100 gm	75	101	25	-	2	
Jam, 200 gm	56	550	142	1	1	
	144	2000	261	77	69	

* Alternate menus for (1).

(a) Meat Bar, 40 gm/meal
Cereal Bar, 60 gm/meal
Jelly Bar, 1 at 2 meals
Spice Drops, 40 gm for 1 meal

(b) Pineapple 100 gm (67 gm solid, 33 ml juice) = 78 gm water, 48 Cal, 21 gm CHO used to replace 20 gm Spice Drops.

E. Composition of Polar Rations Used by Peary and Amundsen.

Peary's Diet (Mar/Apr) North Pole Expedition of 1909

	Cal	CHO	Fat	PRO
Pemmican - 1 lb	2090	83	107	210
Biscuit - 1 lb	2150	330	72	44
Condensed milk 4 oz	384	66	10	10
Total	4524	479	189	264
% calories		(41%)	(37%)	(23%)

In order to make an analysis of this diet, certain assumptions were made:

1. Pemmican - stated to contain "dried beef, fat and raisins", with less fat than beef. Therefore it is assumed that the pemmican contained 50% dried beef, 25% fat and 25% raisins.

2. Ships Biscuit - Figures for the 5-in-1 cracker item were used.

3. Condensed milk.

Amundsen's Diet (Mar/Dec) South Pole Expedition of 1911

	Cal	CHO	Fat	PRO
Pemmican 350 gm	1780	90	110	116
Biscuits 400 gm	1824	280	48	68
Powdered Milk 120 gm	436	62	2	44
Chocolate 40 gm	188	25	12	1
Total	4228	457	172	229
% calories		(43%)	(37%)	(22%)

473

Assumptions made for Analysis:

1. Pemmican - text stated in addition to the usual equal weights of dried beef and fat, that oatmeal and vegetables were added. Therefore it was assumed that it contains 65% beef and fat (equal weights) 20% oatmeal, 15% vegetables (figures for dried carrots used).

2. Biscuits - The text listed only number of biscuits (40) used per day in one place and total weight of a large package in another, from which it could be estimated that each biscuit weighs 10 grams. The text also described them as made with "oatmeal, dried milk and a little sugar".

3. Powdered Milk - assumed to be skimmed, as powdered whole milk is a recent development. The text lists 60 grams per man per day, but later stated that each 10 1/2 oz package was enough for one meal for five men. Since they ate twice a day, the figure of 120 gram was used.

4. Chocolate - assumed to be sweet chocolate.

Hanson's Diet (Man/Day) Expedition to Victoria Land in 1905.

	Cal	CHO	Fat	PRO
Pemmican 200 grams	3208	-	92	90
Bread 360 grams	840	160	3	26
Margarine 30 grams	216	-	24	-
Chocolate 200 grams	1078	111	67	17
Green stuff 25 grams	5	1	-	
Pea flour 5 grams	20	4	-	1
Dried billberries 5 grams	15	4	-	-
Sugar 5 grams	20	5	-	-
Total	3372	285	186	134
% calories		(33%)	(50%)	(16%)

Assumptions made for analysis:

1. Pemmican stated earlier in text as equal parts, dried beef and fat.

2. Bread - apparently fresh, from ship's baker.

3. Chocolate - sweet

4. Green stuff - spinach figures used.

5. Pea flour - regular flour figures used.

6. Dried Billberries - raisin figures used.

Lockhart. Lockhart calculated the composition of some of these same diets. His figures for pemmican was 154 Cal/oz, whereas ours was 145 Cal/oz. If Lockhart's figures for Ammundsen's pemmican are used, the daily issue was 4523 Cal/man, with a distribution of calories: 40% CHO, 43% Fat, 18% Protein. However, Lockhart omitted the oatmeal which Amundsen stated he used.

STAT
STAT

APPENDIX IV

CASE HISTORIES

CASE HISTORIES: GROUP I

Subject No. 1

Original Anamnesis. Young negro male, aged 21 years. No spontaneous complaints. Past history: Non-contributory except for rheumatic fever in childhood; no subsequent physical impairment. Sensitivity to penicillin and distaste for chocolate. Family history of asthma and bacterial endocarditis. Physical examination: Well developed, well nourished young negro male. Height, 68 in; weight, 152 lb; pulse, 66; blood pressure, 115/75. Significant positive findings were gingival hypertrophy, epidermophytosis, shotty nodes bilaterally in groin, soft blowing precordial systolic murmur lowest at the apex, and diminished right knee jerk. Admission hematology and urinalysis within normal limits. Electrocardiogram and chest plate read as normal.

Progress Notes.

Phase I, control period (6-19 Jan.): 6 Jan. Sore throat since 4 Jan. [illegible] symptoms generally diminished; no further complaints. 13 Jan. Physical examination revealed no significant changes.

Phase I, experimental period (19 Jan-1 Feb.): 21 Jan. Chewing gum to ameliorate sensation of thirst; tongue appeared moist. 23 Jan. Complaining of thirst, tongue appeared moist. 24 Jan. Complaining of dry mouth. 25 Jan. States that salivary secretions are diminishing. 26 Jan. Subject appears tired; he has been staying up late studying; complains of fatigue and lack of ambition. 27 Jan. Continued complaints of fatigue and dry mouth. 28 Jan. Reports that salivary flow seems to have increased although mouth is still dry and he is still thirsty; able to swallow food more easily than during past few days. 29 Jan. Physical examination revealed no significant changes. 31 Jan. States that drinking cold water causes abdominal cramps. 1 Feb. During water diuresis test he experienced a cold sensation "deep inside" at the level of the lumbar vertebrae.

Phase I, recovery period (2-8 Feb.): 2 Feb. Rapid recovery from limited water regimen. 3 Feb. Some anorexia and abdominal cramps; he has reduced his intake of meat; claims to be constipated. 4 Feb. Appetite returning.

Phase II, pre-period (9-15 Feb.): No complaints.

Phase II, experimental period (16-26 Feb.): 17 Feb. Mild hunger pangs. 18 Feb. Feels "nauseated" and weak; depressed; on questioning, "nausea" was found to mean emptiness and hunger. 19 Feb. Improved spirits. 20 Feb. Complains of inability to

STAT
STAT

think clearly and act efficiently. 21 Feb. Weakness increasing; blacking out on assuming an erect posture; difficulty sleeping because of cramps and restlessness. 22 Feb. Cramps, weakness, and blackouts continue. 23 Feb. More intense blackouts. 24 Feb. Improvement.

Phase II, recovery period (27 Feb. - 8 Mar.): 27 Feb. Broke fast. 28 Feb. Physical examination revealed evidence of weight loss and two swollen moderately tender hemorrhoids at 2 o'clock (had been present two days). 3 Mar. Hemorrhoids responding to symptomatic treatment. 6 Mar. Itching of hemorrhoids.

Phase III, pre-period (9-15 Mar.): 14 Mar. Physical examination revealed well-nourished, well developed negro; significant findings were shrunken (asymptomatic) hemorrhoids, absent right knee and ankle jerks, and absent left cremasteric reflex.

Phase III, experimental period (16-29 Mar.): 19 Mar. Beginning to feel dehydrated. 20 Mar. Blacking out. 21 Mar. Thirsty. 22 Mar. Thirsty. 23 Mar. Thirsty. 24 Mar. Vomited once after injection of fluorescein used to determine circulation time; onset sudden with no residuum. 25-28 Mar. No new complaints. 29 Mar. Physical examination revealed evidence of recent weight loss, glossal tooth markings, absent quadriceps and Achilles' reflexes, and small hemorrhoidal tab at 3 o'clock: murmur and gingival hypertrophy unchanged.

Phase III, recovery period (30 Mar. - 5 April): No complaints.

Phase IV, pre-period (6-12 April): 7 Apr. Vomiting again during injection of fluorescein; injections will be discontinued. 12 Apr. Physical examination revealed right knee jerk was absent with reinforcement, left knee jerk was present with reinforcement, ankle jerks were absent, and disappearance of hemorrhoidal tabs; other original findings unchanged.

Phase IV, experimental period (13-26 April): 13 Apr. Hungry. 14 Apr. Hungry. 15 Apr. Tired. 18 Apr. Physical work made him feel better. 19 Apr. Hungry. 20-21 Apr. Tired and hungry. 22 Apr. Tired and hungry; several spells of light-headedness. 24 Apr. Reports that he has been nauseated for past two days and almost vomited last night; nervous and high-strung; has been drinking more coffee than usual. 26 Apr. Significant physical findings were weight loss, absent left triceps reflex, bilaterally absent knee jerks, right ankle jerk inactive, and abdominal and right cremasteric reflexes inactive.

Phase IV, recovery period (27 April - 3 May): No complaints.

Phase V, pre-period (4-10 May): No complaints. 10 May Positive physical findings differing from initial examination were

left knee jerk hypoactive without reinforcement but hyperactive with reinforcement, right knee jerk inactive, right ankle jerk inactive, and right abdominal reflexes absent.

Phase V, experimental period (11-24 May): 12 May. Although on limited water, reported that at 1 A.M. this morning he suddenly remembered he had 300 ml of water left in his daily rations; he is not thirsty. 14 May. Teeth hurt because candy diet. 17 May. Transient blackout once while at dance. 20 May. Complains of being sleepy most of the time. 21 May. Tired at the end of a four-hour lab. 22 May. Blackout spells not severe or common. 24 May. Significant physical findings were tooth markings on tongue, hypertrophy of lower gums looks "healthier" than on previous examinations, [illegible] bleeding on pressure; (subject volunteers that he had no canker sores and that gums have felt better on present regimen), murmur unchanged, knee jerks inactive, left ankle jerk hypoactive, right ankle jerk inactive, pin-prick generally felt sharp, and upper abdominal reflexes more active than lower.

Phase V, recovery period (25 May - 1 June): 25 May. Two loose stools. 27 May. "Gas in intestine" and thinks loose stools may [illegible] starting again; paregoric, 5 ml in A.M.; aspirin gr x for toot[illegible] in P.M. 31 May. Positive physical findings were gingival hyp[illegible], with bleeding on pressure, precordial blowing systolic murm[illegible], positive right and inactive left knee jerk and inactive ankle jerks bilaterally. 1 June. End of study.

Terminal Procedures. Chest plate and EKG read as normal. Body weight on 10 June 151 3/4 lb.

Subject No. 2.

Original Anamnesis. Young white male, aged 23 years. No spontaneous complaints. Past history and family history non-contributory, except for scarlet fever at age 13, from which an uneventful recovery was made. Veteran of World War II. Physical examination: well developed, well nourished white male. Height, 66½ in; weight, 156 lb; pulse 80; blood pressure, 105/70. Significant positive findings were epidermophytosis, and knee jerks bilaterally elicited only with reinforcement. Admission hematology and urinalysis within normal limits. Electrocardiogram and chest plate read as normal. Latter showed probable healed Ghon complex on left.

Progress Notes.

Phase I, pre-period (6-18 Jan.): 6 Jan. Headache all day; developing rhinitis. 7 Jan. Cold clearing; hungry before meals. 8 Jan. Cold settling in chest and stomach; some anorexia. 9 Jan. Coughing, headache; oral temp, 99.0°F; W.B.C. and differential

STAT
STAT

normal; no medication. 10-11 Jan. Cold breaking up. 13 Jan. Physical examination revealed split M_1; otherwise no significant changes. 18 Jan. Fallen arch in left foot due to one mile run; weakness originated during service; anorexia at suppertime.

Phase I, experimental period (19 Jan. - 1 Feb.): 28 Jan. No split M_1 detected during physical examination; no other significant changes.

Phase I, recovery period (2-8 Feb.): 5 Feb. Complaining of burning sensation in anal region, especially during defecation; examination of anus revealed no abnormalities.

Phase II, pre-period (9-15 Feb.): 13 Feb. General malaise, ear ache, sore throat, and anorexia; oral temperature, 99.1°F, right ear drum dull with normal light reflex, mild follicular pharyngitis, submaxillary node on left side tender; 250 mg of aureomycin q 4h x 6 doses. 14 Feb. Marked improvement, no fever, some nasal congestion, malaise largely disappeared; stated that he experienced chills during night. 15 Feb. Feeling fine again.

Phase II, experimental period (16 Feb. - 1 Mar.): 17 Feb. Mild hunger pangs and weakness. 18 Feb. Some weakness in knees. 19 Feb. Severe hunger sensations which progress as the day continues; moody and depressed. 21 Feb. Weakness increasing and tendency to black-outs has appeared. Loose stools for which paregoric was given. 22 Feb. Complaining of weakness, black-outs, and post-nasal drip; feels "rotten" and thinks he is coming down with cold; intense abdominal cramps. 23 Feb. Coughing during night; examination of chest within normal limits; no fever; marked intestinal cramps relieved by passage of watery stool; burning of urethra; bought a cook book to read. 24 Feb. Slept poorly during night; post-nasal drip and laryngitis; cramps less severe. 25 Feb. More loose stools but cramps have subsided. 26 Feb. Water stools again for which more paregoric was given; weak and tired. 27 Feb. Some improvement. 28 Feb. Nauseated during water diuresis test; watery stools continue; rectal examination negative for impaction. 1 Mar. Continued intermittent diarrhea. Physical examination revealed a thin moderately emaciated young male who was tired and depressed; significant positive findings were moderate café au lait coating on tongue, absent triceps reflexes, absent right ankle jerk, and absent left abdominal and cremasteric reflexes.

Phase II, recovery period (2-8 Mar.): 2 Mar. Broke fast. Breakfast consisted of 150 ml of beef bouillon, 23 gm of Starlac as milk, four slices of toast, one cube of sugar, and one jelly bar; while walking to class he experienced difficulty in walking; had difficulty concentrating during first class and 45 minutes later experienced sudden onset of intense vertigo which lasted three to four minutes; legs felt unsteady and he had difficulty walking; felt better after pushing car stuck in snow, but five minutes

later again felt "washed out;" in next class he had difficulty writing and again developed intense vertigo; he became exhausted and fell asleep, transient diplopia about 10 A.M.; severe headache; depressed; returned to hospital and went to bed; restless; had dreams; intense hunger during entire episode; soup, Starlac, and ice cream for lunch; fasting blood sugar 50 mg/100 ml; impression, spontaneous hypoglycemia; kaopectinate started for diarrhea. 3 Feb. No further symptoms of hypoglycemia and diarrhea under control with high protein, low residue diet and kaopectinate. 4 Feb. Marked improvement; one soft formed stool; late in the evening he experienced sudden onset of abdominal cramps and nausea; review of food intake revealed that he had eaten large amounts of butter, cocoa, and ice cream at evening snack. 5 Feb. Cramps, abdominal tenderness and nausea persist; kaopectinate stopped. 6 Feb. Severe headache; aspirin gr x; heart burn which began two days ago has subsided. 7 Feb. Heart burn and headache; no medication. 8 Feb. Improvement.

Phase III, pre-period (9-15 Mar.): 9 Mar. Weakness. 11 Mar. Complaining that "strength" has not returned. 12 Mar. Coming down with common cold. 13 Mar. Respiratory symptoms have subsided.

Phase III, experimental period (16-29 Mar.): 16 Mar. Physical examination revealed no significant abnormalities, except that even with reinforcement the knee jerks could not be elicited. 18 Mar. One external hemorrhoid at 4 o'clock which has been bothering him for past two days; symptomatic treatment. 19 Mar. Complains that diet (meat bar) is making him sleepy and interfering with study habits. 20 Mar. Legs tired; hungry; gagging on meat bar. 21 Mar. Tired and hungry; abdominal cramps accompanying passage of one loose stool. 22 Mar. Abdominal cramps and loose stools. 23 Mar. Meat bar becoming more acceptable; hungry. 24 Mar. Small loose stools, gripping abdominal pain, and rectal burning. 25 Mar. Reduction of gastrointestinal complaints; no evidence of inflammation in anal region; hemorrhoid almost gone. 26 Mar. Hungry. 27 Mar. Having difficulty swallowing meat bar; tastes like "sandpaper." 28 Mar. Hungry. 29 Mar. Physical examination revealed recent weight loss, café au lait coating on tongue, glossal tooth markings, absent left triceps reflex, and absent quadriceps reflex bilaterally; gastrointestinal symptoms gone; reported gradual decrease in desire for water, all that was needed was "enough to get the meat bar down," phenomenon most marked during last few days of regimen.

Phase III, recovery period (30 Mar. - 5 April): 30 Mar. Granular feeling in mouth gone, "vigor" returned promptly with immediate disappearance of sluggishness of both mind and body.

Phase IV, pre-period (6-12 Apr.1): 7 Apr. Heart burn and indigestion. 8 Apr. Loose stools, heart burn, malaise, fatigue, and headache. 9 Apr. No complaints. 12 Apr. Physical exam-

ination revealed only a mild hyperkeratosis on elbows bilaterally.

Phase IV, experimental period (13-26 Apr.): 13 Apr. Hungry; given penicillin and streptomycin for infected cut wrist. 14 Apr. Hungry; would rather starve than eat 1000 Cal/day. 15 Apr. Think he has a mild cold; states that meat bar again is causing grating sensation on tongue. 16 Apr. Feeling better. 18 Apr. Tired and sleeping at almost every opportunity; now feels that he would rather eat 1000 Cal than starve. 19 Apr. Hungry. 20-21 Apr. Tired and hungry. 22 Apr. Hungry, tired, and depressed; headache and general malaise (? from late study hours); blacking-out more than during starvation. 24 Apr. Hunger and fatigue; thirst has not been complained of. 26 Apr. Only significant physical findings were weight loss and hyperesthesia to pin-prick over entire body.

Phase IV, recovery period 27 Apr. - 3 May): 29 Apr. In the evening tired, depressed, and anorectic; nausea; watery stools; started kaopectinate. 30 Apr. Watery stools and kaopectinate. 1 May. Symptoms and treatment stopped. 2-3 May "Heart burn."

Phase V, pre-period (4-10 May): 7 May. 30 mg benzidrine sulfate in last 24 hr. 10 May. Positive physical findings were hyperkeratosis on elbows, tooth markings on tongue, and hyperesthesia to pin-prick over lower extremities.

Phase V, experimental period (11-22 May): 12 May. Hungry, but not thirsty. 13 May. Hungry. 16 May. Tired and lacking in normal physical stamina (? late study hours). 17 May. Hunger and fatigue. 18 May. Decided to try and maintain bod weight by forcing water; having considerable difficulty drinking much extra water. 21 May. Weak; has lost his "muscle tone." 22 May. Complaining of loss of physical stamina: exertion in gym class results rapidly in fatigue and breathlessness.

Phase V, recovery period (23 May - 1 June): 24 May. Only significant physical findings were moderate hyperkeratosis on elbows and split lip. 27 May. 10 mg benzidrine sulfate at 11 A.M. 31 May. Significant physical findings were soft blowing apical systolic murmur which disappears with exercise and absent left cremasteric reflex. 1 June. Metabolic regimen ended.

Terminal Procedures. No change in pulmonary picture since original chest plate; E.K.G. showed left axis deviation and inverted T_3 which had been present in the original E.K.G. Weight on 10 June 153 3/4 lb.

Subject No. 3.

Original Anamnesis. Young white male, aged 25 years. No spontaneous complaints. Past history: two nasal plastic pro-

cedures for deformity during military service in Korean War; frequent spontaneous epistaxis. Family history non-contributory. Physical examination: well developed, well nourished white male. Height, 70 3/4 in; weight, 184 3/4 lb; pulse, 90; blood pressure, 120/85. Significant positive findings were large perforation of nasal septum, few very small shotty nodes in inguinal region bilaterally, deep tendon reflexes moderately hypoactive, and webbing of third and fourth toes from base to distal phalanx. Admission hematology and urinalysis within normal limits. Electrocardiogram and chest plate read as normal.

Progress Notes.

Phase I, pre-period (6-18 Jan.): 13 Jan. Significant new physical findings were pterigium on inner aspect of right eye, dilated capillaries and slight erythema of skin in region of manubrium with similar lesions about size of silver dollar between vertebrae and right scapula, epidermophytosis, absent cremasteric reflex on left, and diminished sense of pain over all areas of body except cheeks and lower back. 16 Jan. Complains of inability to sleep.

Phase I, experimental period (19-27 Jan.): 19 Jan. Complaining of "dry heaves." 21 Jan. No complaints; tongue moist. 23 Jan. Complaining of thirst; tongue moist; fatigued and lacking ambition. 24 Jan. Complaining of dry mouth. 25 Jan. Complaining of dry mouth and fatigue; slept much of the day. 26 Jan. Looks tired and complains of dry mouth; has been up late at night studying; states that nutrient mixture (meat bar and cereal biscuit) is increasingly difficult to swallow; it keeps "repeating." 27 Jan. Reported that he vomited small amount of "bile-stained material;" states that he is tired, unsteady on his feet, and completely lacking in ambition; watery feces two days ago and none since; general malaise; ration has become distasteful, the sight or smell of it causing nausea; nauseated all day; "weak feeling in stomach," but no cramps; dry mouth; no remarkable physical findings. Impression: not suffering from significant dehydration syndrome; stress of unusual diet and final examinations has made diet more unbearable than might otherwise be the case; emotionally upset; difficulty with ration real and probably largely due to limited water. Given two-hour test and intravenous injection of antipyrine and sodium thiosulfate.

Phase I, recovery period (28 Jan. - 8 Feb.): 28 Jan. Pale and "all in;" spent a good deal of time sleeping. 29 Jan. Marked improvement; some phlebitis at site of intravenous injection; hot packs. 30 Jan. Phlebitis subsiding. 5 Feb. Phlebitis has cleared; vein thrombosed.

Phase II, pre-period (9-15 Feb.): No significant complaints.

Phase II, experimental period (16-24 Feb.): 17 Feb. Mild

STAT
STAT

hunger pangs and weakness. 17 Feb. Vertigo on assuming suddenly an erect posture. 20 Feb. Pale but not very weak or tired. 21 Feb. Marked increase in weakness and black-outs; difficulty sleeping because of restlessness and cramps. 22 Feb. Marked weakness and pains in knees. 23 Feb. Restless; abdominal cramps; inability to concentrate; burning urethra; bought cook book to read. 24 Feb. Restless; abdominal cramps; physical examination revealed following positive findings: glossal tooth markings, desquamation on shins, inactive triceps and quadriceps reflexes, and decreased reaction to pin-prick over abdomen, lumbar region, and extremities.

Phase II, recovery period (25 Feb. - 8 Mar.): 25 Feb. Broke fast 26 Feb. Complaining of "fullness in chest due to food which is not easily swallowed;" indigestion with anorexia, abdominal cramps and abdominal tenderness all of which may have been due to eating 500 gm of fruit cocktail; rectal reveals no impaction. 27 Feb. Symptoms of indigestion continue. 28 Feb. Feeling better and eating well; symptoms have abated completely.

Phase III, pre-period (9-15 Mar.): 9 Mar. States that he "fills up" rapidly on meals and has difficulty eating all of his food. 15 Mar. Physical examination revealed continued reduction in pain sense and some reduction in sense of light touch, normal deep tendon reflexes, and absent cremasteric reflexes.

Phase III, experimental period (16-29 Mar.): 18 Mar. Feels dehydrated. 21 Mar. Thirsty. 29 Mar. Physical examination revealed continued reduced reaction to pin-prick and hypoactive quadriceps reflexes.

Phase III, recovery period 30 Mar. - 5 April): 1-4 April. Off diet for personal trip to Chicago. No complaints.

Phase IV, pre-period (6-12 April): 12 April. Positive physical findings were tooth markings on tongue with moderate café au lait coating, hypoactive knee jerks, continued depressed sensitivity to pin-prick, and absent lower abdominal and cremasteric reflexes.

Phase IV, experimental period (13-26 April): 15 April. Chocolate bar a greasy tasteless mass; no gastrointestinal complaints; legs are tired and he cannot climb stairs with the usual facility. 16 April. Has been allowed to substitute crackers and oleomargarine for chocolate bar; tired; nauseated; loose stools; spent afternoon in bed. 19 April. Symptoms still present although less intense; cramps and nausea minimal; no diarrhea. 20 April. Weakness in legs. 22 April. Weakness and tired in legs. 23 April. Nausea from chocolate bar; majority of calories from oleomargarine and crackers. 24 April. Cannot consume 2000 Cal/day even though he is hungry. 26 April. Positive

physical findings were bilaterally absent triceps reflex; absent knee jerks bilaterally, more "normal" reaction to pin-prick on back, thighs, and upper arm with continued chillings on lower arms and legs and abdomen.

Phase IV, recovery period (27 Apr. - 3 May): No complaints.

Phase V, pre-period (4-10 May): 10 May. Significant positive findings on physical examination were bilaterally absent knee jerks and generally diminished reaction to pin-prick.

Phase V, experimental period (11-26 May): 11 May. Complained [illegible] stool. 12 May. Positive physical findings were depression, irritability, and tired appearance, moderate coating of tongue, absent knee jerk bilaterally, continued reduced reaction to pin-prick, sense of light touch diminished over legs, absent lower abdominals, and absent cremast ric reflexes, although there was spontaneously scrotal activity.

Phase V, recovery period (28 May - 1 June): No complaints. Positive findings on physical examination were spider hemangiomata in the umbilavicular area near manubrium, small pimple on shaft of penis, and unchanged neurological reactions. 1 June. Metabolic regimen ended.

Terminal Procedures. E.K.G. and chest plate read as normal. Weight on 10 June was 179 lb.

Subject No. 4

Original Anamnesis. Young white male, aged 25 years. No spontaneous complaints. Past history: pneumonia, age 12; infectious mononucleosis, age 23. Family history non-contributory. Physical examination: well developed, well nourished young male. Height, 72 5/8 in; weight, 182 lb; pulse, 90; blood pressure, 130/90. Significant positive findings were epidermophytosis, faint apical systolic murmur and split second sound which persisted with exercise, large (1.5 in) moderately tender lymph node in left axilla; and small (0.5 in) node in right axilla. Admission hematology and urinalysis within normal limits. Electrocardiogram and chest plate read as normal.

Progress Notes.

Phase I, pre-period (6-10 Jan.): 13 Jan. Significant positive changes in physical examination were tooth markings on tongue, right cremasteric inactive, and split M_1.

STAT
STAT

Phase I, experimental period (19 Jan. - 1 Feb.): 20 Jan. Post-cibal abdominal cramps probably due to eating too rapidly; sore throat with slight injection of posterior pharynx. 22 Jan. Sore throat almost gone; headache. 26 Jan. No special complaints; looks tired probably due to late hours studying; on direct questioning stated that he was not thirsty and could readily go without much water between meals. 27 Jan. Physical examination revealed nothing other than slightly coated tongue; states that regimen (meat bar and cereal biscuit) makes him nauseated in the morning both before and after breakfast with symptoms abating somewhat during the remainder of the day, has "sick feeling" in abdomen, and less frequent stools than usual; subject has decided to resign from experiment for various personal reasons at the end of Phase I. 1 Feb. States that morning nausea gradually disappeared during the second week; the remarkable observation was the lack of desire to consume large quantities of water.

Phase I, recovery period (2-8 Feb.): No complaints.

Subject No. 12

Original Anamnesis. Young white male, aged 24 years. No spontaneous complaints. Past history: myopia and hyperphoria, low grade otitis 1.5 years ago, which responded to penicillin, occasional dull pain in left upper chest, and tendency to psychological upset in the face of emotionally disturbing situations. (About 1.5 years ago he became emotionally upset over ending of romance; felt like he was "shaking inside;" overworked himself and finally developed "general low grade infection;" a hypochondriac according to own statement.) Family history of allergic dermatitis. Physical examination: well developed, well nourished young male with normal mood and affect. Height, 71 3/4 in; weight, 161 lb; pulse, 88; blood pressure, 120/73. Significant physical findings were latent strabismus bilaterally, soft palpable node in left supraclavicular fossa (present for years), and split M_1. Admission hematology and urinalysis within normal limits. Electrocardiogram and chest plate read as normal.

Progress Notes.

Phase II, pre-period (2-15 Feb.): No complaints.

Phase II, experimental period (16-24 Feb.): 17 Feb. Mild hunger pangs and weakness. 18 Feb. Hungry, light-headed, and unsteady on feet. 19 Feb. Vertigo on suddenly assuming erect posture. 20 Feb. Weakness, only complaint. 21 Feb. Increased weakness; more intense blacking-outs; difficulty sleeping due to restlessness and abdominal cramps. 22 Feb. Symptoms accentuated. 23 Feb. Restless; abdominal cramps; weak; light-headed and easy fatigability; spent evening cutting out recipes and pictures of food. 24 Feb. Restless; abdominal cramps; physical examination

revealed evidence of recent weight loss, moderate coating of tongue, left quadriceps reflex less active than right, and absent abdominal reflexes.

Phase II, recovery period (25 Feb. - 8 Mar.): 25 Feb. Broke fast. 8 Mar. Complaining of upper respiratory infection.

Phase III, pre-period (9-15 Mar.): 9 Mar. Mild upper respiratory infection. 10 Mar. Mild sore throat; no elevation of oral temperature; examination revealed moderately injected soft palate, tonsillar pillars, and pharynx; treatment aspergum tabs 11 in morning and evening; considerable relief. 11 Mar. Continued sore throat treated with aspergum tabs at t.i.d. 12 Mar. Rhinitis; no medication. 13 Mar. Mild upper respiratory symptoms with sinusitis. 14 Mar. Symptoms decreasing. 15 Mar. Physical examination revealed some acne on back but no other significant findings.

Phase III, experimental period (16-29 Mar.): 16 Mar. Grinding for dental prep in my own mouth; eyes tired; cold almost gone. 22 Mar. Positive physical findings were acne over shoulders and back; papular rash on skin over sternum, moderate dermographia, bilaterally absent abdominals, and absent left cremasteric reflex.

Phase III, recovery period (30 Mar. - 6 April): 30 Mar. Severe occipital headache during written preliminary examinations; aspirin gr x. 31 Mar. Depressed, moody, and irritable, even though he passed his examinations; 1 Apr. Some improvement in mood. 2-5 Apr. Continued irritability and making of caustic remarks; baiting other subjects; accused subject 3 of cheating.

Phase IV, pre-period (6-12 April): 6-8 Apr. Irritability continued. 9 Apr. Oral examination taken with little improvement in mood. 12 Apr. Except for mild acne on shoulders and back, no significant positive physical findings.

Phase IV, experimental period (13-26 April): 13 Apr. Began 2/20/70 2000 L regimen; nauseated all day and drank practically no water; chocolate bar tasted like wax and he stated that he "would rather starve than eat the stuff;" given crackers and oleomargarine as substitute for chocolate bar. 14 Apr. Nauseated all day. 15 Apr. Nausea decreased, stomach cramps, pains in chest and back on right side, and inability to sleep. 16 Apr. Continued cramps and pain in chest. 18 Apr. Episode of diarrhea. 19 Apr. Continued abdominal cramps; diet increasingly difficult to consume; restless as night; spends a good deal of time in bed. 20 Apr. During last two days has eaten only 50% of caloric intake; cramps persistent; nausea with some clear liquid emesis after breakfast; in the late afternoon experienced the sudden onset of acute dull pain in the R.U.Q. which caused him to double up; acute pain lasted about 30 minutes; examination disclosed no palpable masses or organs, but decreased peristaltic activity and tenderness in R.U.Q. were

STAT

present; dull R.U.Q. pain persisted. 21 Apr. Restless night; persistent dull R.U.Q. pain which was relieved only on doubling up; pain continuous and dull and localized principally near costal margin; chest pain which frequently radiates through to tip of right scapula; states that right nipple has been tender for past three to four days; examination revealed tenderness to deep pressure in R.U.Q. and questionable palpable mass in same area; no anosmia; unable to eat all day principally for fear of precipitating another attack of acute pain; feels tired and hungry and has hunger cramps; in the evening pain was described as "dull drawing" sensation; blacking-out on assuming standing position; since 17 April has noted that legs go to sleep with more than usual ease; became dizzy at the end of voluntary ride on Kinocycle.

Phase IV, recovery period (22 April - 3 May): 22 Apr. Feeling better; no pain during morning; ate light lunch which caused return of pain but attack did not cause him to double up; prepared for gall bladder and gastrointestinal studies. 23 Apr. X-rays taken of gall bladder, stomach, and small bowel; gall bladder, stomach, and small bowel normal; calcified cyst of the liver found; conclusions from X-ray studies: "Solitary 2 cm ring-like calcification in the liver . . . . represents calcification in the walls of an echinococcus cyst." 24 Apr. Started on papaverine and phenobarbital tabs. 1 q.i.d.; feeling better; mood improved; slight discomfort in R.U.Q. 25 Apr. Continued improvement. 26 Apr. Only positive finding on physical examination was slight tenderness to deep pressure in R.U.Q. Impression: biliary dyskinesia; complains of tinnitus which apparently has been present for two months. 27 Apr. Light-headedness, tinnitus, fatigue, and anorexia. 28 Apr. States that left ear is blocked; other complaints continue; has been sleeping well but does not feel rested or refreshed on getting up; medical officer impressed that subject might be developing anxiety state. 29 Apr. - 3 May. Not much change.

Phase V, pre-period (4-10 May): 4 May. Pain in side gradually subsiding. 7 May. Continued improvement. 10 May. No significant positive findings on physical examination.

Phase V, experimental period (11-24 May): 14 May. Spontaneously remarked on decreased desire to drink water; excessive flatus. 21 May. Has been having bouts of black-out. 22 May. States that black-out spells are worse than during starvation. 24 May. Positive physical findings were moderate accentuation of acne on back, moderate coating of tongue, hyperactive triceps reflexes bilaterally, and hyperesthesia to pin-prick.

Phase V, recovery period (25 May - 1 June): 25 May. Tired. 31 May. Tinnitus still present; occasional pressure sensations in left ear; only positive physical finding was mild acne on back. 1 June. Ended metabolic regimen.

Terminal Procedures. Chest plate and E.K.G. read as normal. Body weight on 10 June was 162 lb.

CASE HISTORIES: GROUP II

Subject No. 5

Original Anamnesis. Young white male, aged 22 years. No spontaneous complaints. Past history revealed sensitivity to shrimp and lobster and bronchopneumonia in childhood. Family history non-contributory. Physical examination: well developed, well nourished young male. Height, 68 3/4 in; weight, 144 lb; pulse, 84; blood pressure, 120/60. Significant positive findings were myopia, few small shotty inguinal lymph nodes, and apical systolic murmur which disappeared with exercise. Admission hematology and urinalysis were within normal limits. Electrocardiogram and chest plate read as normal.

Progress Notes.

Phase I, control period (19 Jan. - 1 Feb.): 23 Jan. Headache all day. 24 Jan. Physical examination within normal limits.

Phase I, experimental period (2-8 Feb.): 3 Feb. Reported warm feeling in face and onset of fatigue. Very tired. 5 Feb. Transient vertigo on assuming erect posture; "hot flashes" have disappeared; weak and tired; tea causes nausea. 6 Feb. Felt "cold" during "two-hour" test (c.f., other reactions in Group II). 7 Feb. Intestinal cramps; burning in anal region. 8 Feb. Positive physical findings were slight hyperkeratosis on left, moderately coated tongue, left knee jerk absent, and right knee jerk hypoactive.

Phase I, recovery period (9-22 Feb.): 9 Feb. During the night he was nauseated and experienced severe abdominal cramps. 11 Feb. Abdominal cramps. 12 Feb. Still weak. 13 Feb. Lips dry and chapped but revealed no gross physical abnormalities, moisture brought only temporary relief. 14 Feb. Lips feel normal. 15 Feb. Complaining of "acid indigestion" (heart burn), which interferes with sleep. 16-18 Feb. No complaints.

Phase II, pre-period (23 Feb. - 1 Mar.): No complaints. 1 Mar. Positive physical finding was hyperkeratosis on elbows.

Phase II, experimental period (2-13 Mar.): 4 Mar. Hungry. 6 Mar. Sore throat which cleared up after eating breakfast; uvula and pharynx slightly injected. 7 Mar. For past two days has awakened at night with abdominal cramps which disappear, has had to force himself to drink 500 ml/day; spice drops becoming hard to swallow. 8 Mar. Canker sore; thirsty for first time. 9 Mar. Hunger pangs; muscle cramps in abdomen; canker sore tender; full and full of orders. 10 Mar. Complaining of inability to study and remember (recall of German vocabulary difficult), symptoms

STAT
STAT

which have been present for past 4-5 days; canker sore less annoying. 11 Mar. Canker sore healing spontaneously. 13 Mar. Positive physical findings were dry skin, hypertrophic keratosis on elbows and knees; moderate café au lait coating on tongue, and knee jerks absent bilaterally.

Phase II, recovery period (14-22 Mar.): 16 Mar. Heart burn which is relieved by eating only to reappear two hours post-cibal. 17 Mar. Less heart burn. 18 Mar. No complaints. 20 Mar. Headache; aspirin, gr x.

Phase III, pre-period (23-29 Mar.): No complaints. 29 Mar. Positive physical findings were hyperkeratosis on elbows and knees. Café au lait coating on midline of tongue, triceps reflex absent on left, right knee jerk hypoactive, and left knee jerk absent.

Phase III, experimental period (30 Mar. - 12 April): 30 Mar. Experienced gore repeating of chocolate bar, but had no difficulty swallowing it. 31 Mar. Tired, weak, and unsteady on feet; flushing of skin, room feels warm. 1 Apr. Fatigued at end of day; bad taste in mouth after eating chocolate bar. 3 Apr. Canker sore. 4 Apr. Chocolate bar becoming increasingly tiresome, difficult to swallow, and only small amount can be tolerated at one time; taste flat and repeats; no nausea, vomiting, abdominal cramps, or loose stools. 5 Apr. Fatigue at end of day. 6 Apr. Substituted crackers and oleomargarine for 50% of chocolate bar; ration more acceptable. 8 Apr. Report that for past 3-4 days the extremities --- particularly hands and feet --- go to "sleep" very easily; fatigue and weakness; chocolate bar further reduced. 9 Apr. Upset stomach and nausea before going to bed; pharyngitis and laryngitis today cervical lymphadenopathy; no fever, aspergum and Tracinets. 10 Apr. Sore throat and rhinitis; Tracinets, tabs. i. q.i.d. 11 Apr. Following intravenous injections to determine antipyrine and thiosulfate spaces, he had a moderate pyrogenic reaction; recovery prompt and uneventful. 12 Apr. Positive physical findings were weight loss, hyperkeratosis on knees and elbows, non-tender cervical lymphadenopathy in right anterior chain, canker sore, hypoactive knee jerks, and diminished acuity of reaction to pin-prick over the extremities; pharyngitis and laryngitis markedly reduced.

Phase III, recovery period (13-19 Apr.): 13 Apr. Complaining of dry lips. 13-19 Apr. Persistent heart burn, which is worse than experimental regimen.

Phase IV, pre-period (20-26 Apr.): No complaints. 26 Apr. Positive physical findings were hyperkeratosis on elbows and hypoactive knee jerks.

Phase IV, experimental period (27 Apr. - 6 May): 29 Apr. Tired. 1 May. Pain in region of right kidney accentuated by

breathing. 2-4 May. No further complaints regarding pain; more thirsty on this diet than any other.

Phase IV, recovery period (7-17 May): 10 May. Positive physical findings were hyperkeratosis on elbows somewhat accentuated, moderate coating of tongue, and absent knee jerks.

Phase V, pre-period (18-24 May): Headache; aspirin gr x. 24 May. Positive physical findings were significant reduction of hyperkeratosis on knees and elbows, moderate coating of tongue except in central fissure, absent knee jerks, and increased reaction to pin-prick.

Phase V, experimental period (25 May - 7 June): 5 June. Soreness in right side of neck with associated cervical lymphadenopathy; no sore throat or fever; smear and white count normal. 7 June. Positive physical findings were hyperkeratosis on elbows and hypoactive left knee jerk.

Phase V, recovery period (8-13 June): 8 June. Headache; aspirin gr x. 12 June. Non-tender cervical lymphadenopathy still present. 13 June. Ended metabolic regimen.

Terminal Procedures. E.K.G. and chest plate read as normal.

Subject No: 6

Original Anamnesis. Young white male, aged 20 years. No spontaneous complaints. Past and family history non-contributory. Physical examination: well developed, well nourished young male. Height, 67½ in; weight, 142 2/3 lb; pulse, 80; blood pressure, 110/75; no significant positive findings. Admission hematology and urinalysis within normal limits. Electrocardiogram and chest plate read as normal.

Progress Notes.

Phase I, pre-period (19 Jan. - 1 Feb.): 22 Jan. Headache. 28 Jan. Only positive physical finding was some acne on face with pustules.

Phase I, experimental period (2-10 Feb.): 2 Feb. Drank less than 800 ml H_2O; desire for water had decreased. 3 Feb. Again drank less than 800 ml H_2O. 4 Feb. Tired. 5 Feb. Onset of transient vertigo on assuming an erect posture; tea causes nausea. 7 Feb. Tired and weak. 9 Feb. Passed hard stool which caused pain; no bleeding; complained of forgetfulness. 10 Feb. Marked weakness; mouth dry; slight emesis during body water test; positive physical findings were tiredness, weight loss, and moderate coating of tongue.

Phase I, recovery (11-22 Feb.): 11 Feb. Feels nauseated this morning, which he attributes to tea last night; watery stool, paregoric, 7 ml. 12 Feb. No loose stools. 13 Feb. Dry chapped lips which are not grossly abnormal. 14 Feb. Lips still feel dry. 15 Feb. Lips still feel dry; complaining that he has had "acid indigestion" since breaking fast, worse at night making sleep difficult. 16-19 Feb. No further symptoms of acid indigestion.

Phase II, pre-period (23 Feb. - 1 Mar.): No complaints. 1 Mar. Positive physical findings were moderate acne on sides of neck behind ears, especially on right; tooth markings on tongue, and absent right lower abdominal reflex.

Phase II, experimental period (2-13 Mar.): 4 Mar. Hungry. 8 Mar. Complains that acne has broken out on face; examination revealed a few pimples on lower jaw. 9 Mar. Increasing fatigability and lack of ambition. 10 Mar. Having difficulty reading and recalling content of text; requires great effort to concentrate and make an abstract; has desire to drink no more than one quart of water per day. 11 Mar. Tired.

Phase II, recovery period (14-22 Mar.): 15 Mar. Positive physical findings were acne on face and shoulders, soft blowing precordial murmur, and hyperesthesia to pin-prick. 16 Mar. Heart burn, which is relieved by food but reappears two hours post-cibal. 17 Mar. Less heart burn.

Phase III, pre-period (23-29 Mar.): No complaints. 29 Mar. Positive physical finding was tooth markings on tongue; no murmur heard and reaction to pin-prick normal.

Phase III, experimental period (30 Mar. - 24 Apr.): 30 Mar. Greasy nature of chocolate bar made swallowing it difficult. 1 Apr. Fatigue at end of day; bad taste in mouth. 4 Apr. Chocolate bar becoming tiresome and difficult to swallow; only small amount can be tolerated at one time; taste flat and repeats; no nausea, abdominal cramps, or loose stools. 5 Apr. Fatigue at end of day. 6 Apr. Because of intolerance for chocolate bar, intake reduced 50% and crackers and oleomargarine added. 8 Apr. Report that for last 3-4 days extremities - hands and feet in particular - go to "sleep" very easily; fatigue and weakness; intake of chocolate bar further reduced. 9 Apr. Tired and nauseated. 10 Apr. Tired. 12 Apr. Positive physical findings were mild acne on face, glossal tooth markings; heavy café au lait coating on tongue, and absent lower abdominal reflexes.

Phase III, recovery period (13-19 Apr.): 17 Apr. Complains that he has been having "acid indigestion" since beginning rehabilitation.

Phase IV, pre-period (20-26 Apr.): 22 Apr. Depressed because

of excessive load of class work. 23-25 Apr. Increased frequency of nocturnal omissions during past three weeks. 26 Apr. Positive physical findings were tooth markings on border of tongue, hyperesthesia to pin-prick, and absent lower left abdominal reflex.

Phase IV, experimental period (27 Apr. - 6 May): 29 Apr. Tired. 1 May. Canker sore. 6 May. Meat bar and cereal biscuit diet has interfered less with intellective activity than previous 1000 Cal diets.

Phase IV, recovery period (7-17 May): 10 May. Positive physical findings were weight loss and pin-prick reaction dull on legs; canker sore had healed. No complaints.

Phase V, pre-period (18-24 May): No complaints. 24 May. Positive physical findings were mild coating of tongue and glossal tooth markings.

Phase V, experimental period (25 May - 7 June): 26 May. Complaining of thirst, had difficulty eating 3000 Cal. 27 May. Depressed and frequently gripes about diet; cannot study; thirsty; given 250 ml of extra water because of sweating. 28 May. Complaining bitterly of thirst and sore tongue; states that he is hoarse after 10-15 minutes of talking; tongue heavily coated with thick, furry, café au lait-colored material. 29 May. Tongue moderately coated; hoarse. 30 May. Because of clinical dehydration, given water diversion test and placed on unlimited water; rapid improvement. 7 June. Positive physical findings were moderate acne on chin and sternum, tongue moderately coated with yellow-brown material and external strabismus in left eye.

Phase V, recovery period (8-13 June): No complaints. 13 June. Ended metabolic regimen.

Terminal Procedures. E.K.G. and chest plate read as normal.

Subject No. 7

Original Anamnesis. Young white male, aged 26 years. No spontaneous complaints. Scarlet fever in childhood. Family history non-contributory. Physical examination: well developed, well nourished young man. Height, 71½ in; weight, 147 lb; pulse, 84; blood pressure, 110/70. Positive findings on physical examination were slight enlargement of right lobe of prostate gland, shotty inguinal lymph nodes bilaterally, and epidermophytosis bilaterally. Admission hematology and urinalysis within normal limits. E.K.G. and chest plate read as normal.

Progress Notes.
Phase I, pre-period (19 Jan. - 1 Feb.): No complaints.

STAT
STAT

28 Jan. No abnormal physical findings.

Phase I, experimental period (2-11 Feb.): 3 Feb. Warm feeling, especially on face; tired. 4 Feb. Onset of transient vertigo on assuming an erect posture; hot flashes have largely disappeared; must rest more frequently when walking because of tiredness. 6 Feb. Hyperventilated for no apparent reason during two-hour test and foot felt cold (c.f., reactions of other men of Group II); states that he was unable to breathe normally; apparatus functioning satisfactorily. 7 Feb. Weak and tired. 8 Feb. Passed two stools which were watery; weak. 9 Feb. Weak, tired, and forgetful. 11 Feb. Tired and weak.

Phase I, recovery period (12-22 Feb.): 12 Feb. Water diuresis test made him feel nauseated. 13 Feb. Dry chapped lips which are not grossly abnormal. 14 Feb. Lips still dry, "acid indigestion" since breaking fast; symptoms are more marked at night making sleep difficult. 16-18 Feb. Acid indigestion disappeared.

Phase II, pre-period (23 Feb. - 1 Mar.): No complaints. 1 Mar. Positive physical findings were scratch marks on back, light tan coating on tongue, and absent abdominal and cremasteric reflexes; skin of back has been itching for past five days; no lesions other than scratch marks.

Phase II, experimental period (2-15 Mar.): 3 Mar. Tired especially in the afternoon. 4 Mar. Hunger, easy fatigability, and hunger cramps. 5 Mar. Tired and hungry; slept late; appears fatigued. 6 Mar. Tired; meat bar beginning to "repeat" for about 30 minutes after each meal. 7 Mar. Appears more rested; increasing difficulty swallowing meat bar; tastes like a blob of grease; sticks in throat; feels nauseated. 8 Mar. Tired, weight loss, and beaten-looking; dark circles about eyes; face flushed; complains that food is becoming increasingly difficult to swallow; severe hunger pangs; difficulty studying and remaining wakeful; sleep is deep; because of his deterioration, 1000 Cal/day of carbohydrate will be added and water will remain at 900 ml/day. 9 Mar. After special tests began regimen at noon; no diuresis after water test; B. U. N., 29 mg/100 ml; 83% lymphocytes in smear with mild hypochromia. 10 Mar. Marked improvement in general appearance; states that he has more energy and does not feel so sluggish; mouth dry and lips cracked. 11 Mar. Feeling better but thirst becoming more intense; lips and tongue dry. 12 Mar. Personality change from placid, easy-going manner to bitter and caustic nature: "All you say is 'good'." "You want me to stay on this diet just so you can get data." "You only want those chemists to get the Monday's blood." 14 Mar. Feeling better and more energetic; remarked that when he did not cover meat bar with carbohydrate, he became sleepy as he had on meat bar alone; remarkable biochemical improvement. 15 Mar. Positive physical findings were weight loss, loss of tissue turgor, increased redness of tongue, lips dry and cracked, and increased

reactivity of deep tendon reflexes; complains that skin of back and shoulders still itches although there is no lesion.

Phase II, recovery period (16-22 Mar.): No complaints.

Phase III, pre-period (23-29 Mar.): No complaints. 29 Mar. Positive physical findings were palmar sweating triceps reflex absent on left, knee jerks hyperactive, and lower abdominal reflexes absent bilaterally.

Phase III, experimental period (30 Mar. - 12 April): No complaints. 12 Apr. Positive physical findings were palmar sweating, relatively hyperactive knee jerks, and absent abdominal reflexes.

Phase III, recovery period (13-19 April): No complaints.

Phase IV, pre-period (20-26 April): No complaints. 26 Apr. Positive physical findings were increased weight, reduced palmar sweating, hyperactive knee jerks, and absent left abdominal reflexes.

Phase IV, experimental (27 April - 10 May): 29 Apr. Tired. 6 May. States that he feels much less thirsty than on any previous diet; more hungry. 10 May. Positive physical findings were weight loss, dehydration, thick hairy coat on tongue, and third heart sound clear and distinct.

Phase IV, recovery (11-17 May): 12 May. Awoke most of night with heart burn; symptom continued all day; watery stools which did not respond to paregoric. 13 May. Watery stools all night; began kaopectinate and achieved prompt response. 14 May. Diarrhea ended. 15 May. Third heart sound has disappeared.

Phase V, pre-period (18-24 May): No complaints. 24 May. Only significant physical finding was bilaterally hyperactive knee jerks.

Phase V, experimental period (25 May - 8 June): 25 May. Nauseated. 27 May. Feeling better. 30 May. Irritable, tired, and slightly nauseated; cereal biscuit is nauseous; loose stools. 31 May. Cereal biscuit continues nauseous and revolting. 1 June. Left knee stiff and uncomfortable; no gross abnormalities; stopped cereal biscuit and substituted crackers and jam. 2 June. Feeling better. 7 June. Positive physical findings were weight loss, moderately yellow brown coating of tongue, external strabismus in left eye, and third heart sound. 8 June. Ended metabolic regimen.

Terminal Procedures. E.K.G. and chest plate read as normal.

STAT
STAT

Subject No. 8

Original Anamnesis. Young white male, aged 22 years. No spontaneous complaints. Possible food allergy to chocolate. Family history non-contributory. Physical examination: well developed, well nourished young man. Height, 70½ in; weight, 146 lb; pulse, 90; blood pressure, 120/75. Positive physical findings were myopia, acne vulgaris over face, chin, and back, pigmented nevi over chest and abdomen, epidermophytosis bilaterally, small shotty inguinal nodes bilaterally, and small (1/2 in) soft node in both axillae. Admission hematology and urinalysis within normal limits. Chest plate and E.K.G. read as normal.

Progress Notes.

Phase I, pre-period (19 Jan. - 1 Feb.): No complaints. 28 Jan. Positive physical findings were marked acne on face and back, incipient boil on lateral surface of left forearm, healing boils on right upper arm (patient thinks acne and health of skin deteriorated during final examination period), and dependent vascular stasis denoted by purplish-red coloration of feet which paled on elevating legs (feet not cold, good pulsations).

Phase I, experimental period (2-9 Feb.): 4 Feb. Tired; hunger pangs began last night. 5 Feb. Onset of transient vertigo on assuming an erect posture. 6 Feb. During tre-hour test developed hyperventilation during period of gas collection, associated with tingling sensation in fingers (c.f., reactions of other subjects); acne accentuated; hunger pangs, especially when no thinks of food; 7 Feb. Weak and tired. 8 Feb. Intestinal cramps and extreme weakness in legs; it takes twice as long as usual to walk from Natural History Building to Hospital; thinks acne has regressed now that the examination period is over. 9 Feb. Weak, tired, hunger pangs.

Phase I, recovery period (10-22 Feb.): 10 Feb. Broke fast. 13 Feb. Dry, chapped lips which are grossly normal. 14 Feb. Lips almost normal. 15 Feb. Lips still dry; minimal recovery acid-indigestion. 16-18 Feb. Symptoms of acid indigestion disappeared.

Phase II, pre-period (23 Feb. - 1 Mar.): No complaints. 1 Mar. Positive physical findings were acne reduced in intensity, hyperkeratosis, mild dermographism, and knee jerks briskor than usual.

Phase II, experimental period (2-15 Mar.): 3 Mar. Tired. 4 Mar. Hungry. 5 Mar. Tired and hungry; craves sugar. 6 Mar. Tired, but in much better state than subject on limited water (No. 7). 7 Mar. Fatigue; sleeps as in "drunken stupor" from which he is difficult to arouse. 8 Mar. More alert than No. 7.

9 Mar. Tired; legs feel like "lead weights;" cramps in calves on walking. 11 Mar. Acne markedly reduced; no special complaints. 14 Mar. Positive physical findings were weight loss, acne, mild dermographism, accentuation of epidermophytosis, furry tan coat on tongue in midline, and right upper abdominal reflex absent.

Phase II, recovery period (16-22 Mar.): 17 Mar. Ate large number of peanuts and peanut butter on bread last night; this morning he has abdominal cramps, loose stools, nausea, and vomiting; vomiting produced improvement; only small volume of vomitus. 18 Mar. No complaints.

Phase III, pre-period (23-29 Mar.): No complaints. 29 Mar. Positive physical findings were acne, marked reduction in dermographism, and buff tan coat on tongue.

Phase III, experimental period (30 Mar. - 13 April): 31 Mar. Thirsty. 1 Apr. More thirsty. 2 Apr. Thirsty. 12 Apr. Positive physical findings were reduced acne, very mild dermographism, moderately thick tan coating on tongue, and relatively hyperactive quadriceps reflexes.

Phase III, recovery period (13-19 April): No complaints.

Phase IV, pre-period (20-26 April): No complaints. 26 Apr. Positive physical findings were markedly reduced acne, slight dermographism, relatively hyperactive knee jerks, and legs discoloration of feet due to dependent circulatory stasis.

Phase IV, experimental period (27 April - 10 May): 6 May. Acne more active. 8 May. Little thirst, few black-out spells, and little fatigue. 10 May. Positive physical findings were reduced activity of acniform lesions, less circulatory stasis, thick hairy coat on tongue, canker sore, and marked accentuation of dermographism (intense triple response along scratch-line).

Phase IV, recovery period (11-17 May): No complaints.

Phase V, pre-period (18-25 May): No complaints. 24 May. Positive physical findings were marked reduction in acne on back, acniform lesions moderately active on back, white heads on posterior surface of right forearm below elbow, triple response to dermographism test with moderate edema. Moderate coating of tongue, and hyperactive left knee jerk.

Phase V, experimental period (25 May - 7 June): 26 May. Thirsty, depressed, and nauseated. 27 May. Feeling thirsty; 250 ml of extra water because of sweating. 28 May. Moderately heavy coat on tongue. 29 May. Complaining of aching in legs; pale, weak, and tired; light-headedness on assuming erect posture. 30 May. Feels "lousy," weak, and tired; legs [illegible] less; tongue dry and coated; 500 ml of extra water because of sweating; late

STAT
STAT

in day began to complain of ache in region of kidneys; some tenderness on palpation; fresh specimen of urine collected: specific gravity, 1.034; no albumen; thick mucus; sediment, 2-4 WBC/L.P.F., occasional finely and coarsely granular casts. 31 May. Feels terrible; nauseated, dizzy, weak, tired, depressed, anorectic, pain in legs and high in lumbar region; no sweating; no fever; passed only 195 ml urine in 500 min (0.39 ml/min): specific gravity, 1.036; no albumen; thick mucus; sediment, 2-4 WBC/L.P.F., occasional fine and coarsely granular casts; given water diuresis test in the evening; felt dizzy and then began to sweat profusely during first hour with return of appetite; noted 1+ pitting edema along shinbones at 2230 (four hours after beginning test). 1 June. Placed on unlimited water; edema gone; weak and tired but feeling much improved. 2 June. Continued improvement. 3 June. No complaints. 7 June. Positive physical findings were now quiescent, yellow-brown coating on tongue, hyperactive quadriceps reflexes, no edema, marked reduction in dermographic response; headache; aspirin gr x.

Phase V, Recovery Period (8-13 June): 8 June. Headache; aspirin, gr x. 13 June. Ended metabolic regimen.

Terminal Procedures. Chest plate and E.K.G. read as normal.

CASE HISTORIES: ALTERNATE SUBJECTS

These subjects were used in special experiments designed to validate physiological procedures and gain further data on specific questions regarding experimental nutrient mixtures. Detailed progress notes were not maintained except when these men were participating in actual experiments. A synopsis of pertinent clinical findings is given in connection with such experiments in the main body of the report. The original anamnesis of each man is summarized below.

Subject No. 9

Original Anamnesis. Young white male, aged 25 years. No spontaneous complaints. Bronchopneumonia in childhood; fused 6th and 7th cervical vertebrae (? congenital). Family history non-contributory. Physical examination: well developed and well nourished young man. Height, 67 7/8 in; weight, 150 3/4 lb; pulse, 84; blood pressure, 140/85. Positive physical findings were myopia, epidermophytosis, and small shotty inguinal nodes bilaterally. Admission hematology and urinalysis within normal limits; E.K.G. read as normal. Chest plates reveal normal lungs, mild scoliosis in low cervical and upper lumbar spine, and possible occult, spina bifida at L_1.

Subject No. 10

Original Anamnesis. A young white male, aged 24 years. Spontaneous complaints: concave ear drum which adjusts ineffectively with the left eustachean tube to rapid changes of altitude; postnasal drip which is present the year around unless antihistaminic tablets are taken; bleeding hemorrhoids. Scarlet fever in childhood. Grandfather had Buerger's disease and diabetes mellitus. Physical examination: well developed somewhat obese young man. Height, [illegible] in; weight, 180 lb; pulse, 60; blood pressure, 110/70. Positive physical findings were chronic epidermophytosis, hyperesthesia to [illegible] of feet, and knee jerks absent bilaterally. Admission hematology and urinalysis within normal limits. Chest plate and E.K.G. read as normal.

Subject No. 11

Original Anamnesis. A young white male, aged 26 years. No spontaneous complaints. Myopia and astigmatism; slight sensitivity to chocolate. Veteran of World War II. Family history: tuberculosis and hay fever; mother has abdominal pachonia from which she is recovering successfully. Physical examination: well developed and well nourished young male. Height, 69 in; weight, 143½ lb; pulse, 90; blood pressure, 105/70. No significant physical abnormalities except for myopia. Admission hematology and urinalysis within normal limits. E.K.G. and chest plate read as normal.

APPENDIX V

METEOROLOGICAL DATA

TABLE AV. 1

SUMMARY OF OUTDOOR TEMPERATURES:

Jan. 6-June 13, 1953. Urbana, Ill.*

Dates	Average Maximum Temperature °F	Average Minimum Temperature °F	Average Mean Temperature °F	Highest Temperature °F	Lowest Temperature °F
1/6-1/18	38	26	32	59	6
1/19-2/1	41	28	34	56	14
2/2-2/15	45	28	37	55	21
2/16-3/1	46	26	36	58	7
3/2-3/15	47	31	39	70	18
3/16-3/29	56	37	47	73	28
3/30-4/12	56	39	48	79	34
4/13-4/26	59	37	48	82	26
4/27-5/10	70	48	59	81	40
5/11-5/24	72	52	62	86	40
5/26-6/7	85	60	73	90	47
6/8-6/13	89	66	79	93	64

*Meteorological data furnished through the courtesy of the Illinois State Water Survey Division in publications entitled "Champaign-Urbana Weather Summary" Jan., Feb., Mar., Apr., May and June, 1953.

APPENDIX V

METEOROLOGICAL DATA

TABLE AV. 1

SUMMARY OF OUTDOOR TEMPERATURES:

Jan. 6-June 13, 1953. Urbana, Ill.*

Dates	Average Maximum Temperature °F	Average Minimum Temperature °F	Average Mean Temperature °F	Highest Temperature °F	Lowest Temperature °F
1/6-1/18	38	26	32	59	6
1/19-2/1	41	28	34	56	14
2/2-2/15	45	28	37	55	21
2/16-3/1	46	26	36	58	7
3/2-3/15	47	31	39	70	18
3/16-3/29	56	37	47	73	28
3/30-4/12	56	39	48	79	34
4/13-4/26	59	37	48	82	26
4/27-5/10	70	48	59	81	40
5/11-5/24	72	52	62	86	40
5/26-6/7	85	60	73	90	47
6/8-6/13	89	66	79	93	64

*Meteorological data furnished through the courtesy of the Illinois State Water Survey Division in publications entitled "Champaign-Urbana Weather Summary" Jan., Feb., Mar., Apr., May and June, 1953.

501

STAT

TABLE AV. 2

STATE WATER SURVEY DIVISION
CHAMPAIGN - URBANA WEATHER SUMMARY

January 1953

Date	Temperature (°F) Max.	Min.	Mean	Precipitation Amt.	Type	Wind Dir.	Speed	Sky Condition
1	40	32	36	0		S	7	Pt. Cloudy
2	37	31	34	.21	RSS	NNW	9	Cloudy
3	31	21	26	.07	S	NW	10	Cloudy
4	30	16	23	.T	S	NW	8	Cloudy
5	31	16	24	.03	S	NW	9	Pt. Cloudy
6	21	6	14	.08	S	NNE	6	Cloudy
7	27	15	21	.T	R	ENE	10	Cloudy
8	34	27	31	.80	R	N	8	Cloudy
9	33	31	32	.T	L	N	9	Cloudy
10	36	31	34	.T	L	N	9	Cloudy
11	34	24	29	0		NW	12	Pt. Cloudy
12	42	17	30	0		S	11	Clear
13	56	36	46	0		SSW	9	Clear
14	55	43	49	T	R	S	9	Cloudy
15	59	33	46	.01	R	S	14	Cloudy
16	26	16	21	.T	S	NW	8	Cloudy
17	33	26	30	.47	RE	ESE	14	Cloudy
18	38	28	33	0		SW	10	Pt. Cloudy
19	37	31	34	.T	L	NNE	3	Cloudy
20	38	32	35	.05	R	NE	7	Cloudy
21	44	31	38	0		NNE	4	Pt. Cloudy
22	39	31	35	.T	RL	SSW	7	Cloudy
23	43	33	38	.53	R	N	7	Cloudy
24	35	26	31	.05	RS	NW	12	Cloudy
25	31	25	28	0		NW	7	Pt. Cloudy
26	42	24	33	0		ESE	9	Pt. Cloudy
27	47	31	39	.T	R	NNW	7	Pt. Cloudy
28	35	18	27	.T	R	WSW	10	Clear
29	39	16	28	.03	S	NW	8	Pt. Cloudy
30	56	36	46	0		SSW	7	Clear
31	55	35	45	.T	R	SSW	10	Clear

Monthly Mean or Total and Departure from Normal

	Temperature (°F) Max.	Min.	Mean	Precipitation Inches	Wind Dir.	Speed (mph)
Mean	38.8	26.5	32.8	2.34	NW	8.6
Dep.	+4.2	+7.6	+6.0	+.30		

Degree Days Total 999 (-141) Accumulate 3100 (-155)

Precipitation Code

R - Rain, S - Snow, L - Drizzle, E - Sleet, RW - Rainshower, TRW - Thundershower, H - Hail.

Sky Cover Code

0-0.3 - Clear; 0.4-0.7 - Partly Cloudy; 0.8-1.0 - Cloudy

TABLE AV. 3

STATE WATER SURVEY DIVISION
CHAMPAIGN - URBANA WEATHER SUMMARY

February 1953

Date	Temperature (°F) Max.	Min.	Mean	Precipitation Amt.	Type	Wind Dir.	Speed	Sky Condition
1	35	14	25			N	8	Clear
2	55	21	38	.T	R	S	9	Pt. Cloudy
3	35	22	29			NNE	5	Pt. Cloudy
4	49	22	36			S	5	Clear
5	51	34	43	.01	R	S	13	Cloudy
6	43	32	38	.10	R	WSW	11	Pt. Cloudy
7	45	27	36			W	5	Clear
8	40	26	33			NW	6	Clear
9	47	27	37			E	7	Pt. Cloudy
10	51	36	44	.T	R	ESE	7	Cloudy
11	50	35	43	.56	R	W	11	Cloudy
12	36	31	34	.T	RS	WNW	10	Cloudy
13	41	26	34	0		SSW	10	Clear
14	47	29	38	0		SSW	10	Pt. Cloudy
15	39	21	30	0		NW	8	Clear
16	31	18	25	.01	S	ENE	11	Cloudy
17	31	7	19	0		WNW	7	Clear
18	57	23	40	0		SSW	12	Clear
19	49	34	42	.T	R	S	10	Cloudy
20	58	45	52	.91	RWTRW	S	14	Cloudy
21	45	17	31	.T	S	W	16	Pt. Cloudy
22	39	13	26	0		SW	10	Clear
23	52	30	41	0		SW	10	Clear
24	48	33	41	0		SW	5	Pt. Cloudy
25	42	31	37	.T	R	C	5	Cloudy
26	54	31	43	.T	R	WSW	14	Clear
27	49	36	43	.T	R	NW	12	Clear
28	47	23	35	.T	R	W	8	Pt. Cloudy

Monthly Mean or Total and Departure from Normal

	Temperature (°F) Max.	Min.	Mean	Precipitation Inches	Wind Dir.	Speed (mph)
Mean	45.2	26.6	36.2	1.49	SW	9.2
Dep.	+8.4	+6.4	+7.7	-.40		

Degree Days Total 807 (-152) Accumulate 3908 (-306)

Precipitation Code

R - Rain, S - Snow, L - Drizzle, E - Sleet, RW - Rainshower, TRW - Thundershower, H - Hail.

Sky Cover Code

0-0.3 - Clear; 0.4-0.7 - Partly Cloudy; 0.8-1.0 - Cloudy

STAT
STAT

TABLE AV. 4

STATE WATER SURVEY DIVISION
CHAMPAIGN - URBANA WEATHER SUMMARY

March 1953

Date	Temperature (°F) Max.	Min.	Mean	Precipitation Amt.	Type	Wind Dir.	Speed	Sky Condition
1	43	22	33	.08	RS	ENE	13	Cloudy
2	32	24	28	.16	SL	E	10	Cloudy
3	37	32	35	1.16	TRW	N	9	Cloudy
4	36	22	29	.08	S	W	12	Pt. Cloudy
5	39	24	32	.01	S	W	9	Clear
6	37	28	33	0		NNE	8	Pt. Cloudy
7	32	21	27	.06	SL	NNE	9	Cloudy
8	33	18	26	0		NW	7	Cloudy
9	47	21	34	0		SSW	7	Clear
10	59	34	47	0		S	6	Clear
11	54	43	49	.03	RL	SE	5	Cloudy
12	55	49	52	.65	RLRW	SE	5	Cloudy
13	60	40	50	0		NE	4	Clear
14	70	37	54	.15	TRW	ENE	9	Cloudy
15	63	39	51	1.81	TRWH	WSW	13	Cloudy
16	52	31	42	0		NNW	8	Pt. Cloudy
17	64	38	51	0		S	7	Pt. Cloudy
18	64	49	57	.52	R	WSW	7	Cloudy
19	52	36	44	0		W	8	Clear
20	54	34	44	0		ESE	7	Pt. Cloudy
21	73	46	60	0		S	14	Clear
22	60	49	55	.10	R	S	9	Cloudy
23	61	45	53	0		WSW	10	Clear
24	52	33	43	.T	S	W	9	Pt. Cloudy
25	40	28	34	.T	S	NNW	8	Cloudy
26	48	29	39	0		NW	7	Clear
27	58	33	46	0		NW	8	Clear
28	56	35	46	0		NW	10	Pt. Cloudy
29	55	33	44	0		N	7	Pt. Cloudy
30	47	35	41	.87	RSW	ESE	8	Cloudy
31	54	41	48	1.45	RWTRW	E	8	Cloudy

Monthly Mean or Total and Departure from Normal

	Temperature (°F) Max.	Min.	Mean	Precipitation Inches	Wind Dir.	Speed (mph)
Mean	51.2	33.9	42.7	7.13	NW	8.4
Dep.	+2.4	+3.4	+3.0	+3.94		
Degree Days Total 688 (-60)				Accumulate 4596 (-366)		

Precipitation Code

R - Rain, S - Snow, L - Drizzle, E - Sleet, RW - Rainshower, TRW - Thundershower, H - Hail.

Sky Cover Code

0-0.3 - Clear; 0.4-0.7 - Partly Cloudy; 0.8-1.0 - Cloudy

TABLE AV. 5

STATE WATER SURVEY DIVISION
CHAMPAIGN - URBANA WEATHER SUMMARY

April 1953

Date	Temperature (°F) Max.	Min.	Mean	Precipitation Amt.	Type	Wind Dir.	Speed	Sky Condition
1	52	41	46	.29	TRW	WNW	8	Cloudy
2	56	41	49	.T	RL	NNW	5	Cloudy
3	53	40	47	.19	RW	W	5	Cloudy
4	54	34	44	0		WSW	9	Pt. Cloudy
5	51	34	43	0		W	4	Pt. Cloudy
6	55	38	47	.02	R	NE	6	Pt. Cloudy
7	56	35	46	0		E	6	Clear
8	59	44	52	.20	TRW	E	9	Cloudy
9	79	47	63	.T	R	S	8	Pt. Cloudy
10	71	43	57	.T	R	W	13	Cloudy
11	52	34	43	0		W	5	Cloudy
12	48	40	44	.01	R	NNE	8	Cloudy
13	53	37	45	.T	S	NW	7	Pt. Cloudy
14	50	31	45	.T	SR	SE	10	Cloudy
15	56	38	47	.21	TRW	S	17	Cloudy
16	54	32	43	.01	R	WNW	13	Clear
17	48	30	39	.19	RS	NW	6	Cloudy
18	44	30	37	.T	RS	N	9	Cloudy
19	39	26	33	.T	S	WNW	9	Cloudy
20	55	31	43	0		WNW	11	Clear
21	63	33	48	0		SSW	9	Clear
22	82	47	65	0		SW	9	Pt. Cloudy
23	77	50	64	0		NNE	5	Pt. Cloudy
24	73	48	61	.30	RW	S	11	Cloudy
25	68	49	59	.05	RW	WSW	14	Pt. Cloudy
26	49	38	44	.T	LRRW	WNW	11	Cloudy
27	57	40	49	0		WNW	7	Cloudy
28	58	44	51	.04	TRW	E	10	Cloudy
29	74	45	60	.T	R	E	9	Pt. Cloudy
30	72	57	65	.07	R	SSE	11	Pt. Cloudy

Monthly Mean or Total and Departure from Normal

	Temperature (°F) Max.	Min.	Mean	Precipitation Inches	Wind Dir.	Speed (mph)
Mean	58.9	39.3	49.3	1.57	WNW	8.8
Dep.	-2.5	-1.1	-1.6	-2.04		
Degree Days Total 471 (+110)				Accumulate 5067 (-256)		

Precipitation Code

R - Rain, S - Snow, L - Drizzle, E - Sleet, RW - Rainshower, TRW - Thundershower, H - Hail.

Sky Cover Code

0-0.3 - Clear; 0.4-0.7 - Partly Cloudy; 0.8-1.0 - Cloudy

TABLE AV. 6

STATE WATER SURVEY DIVISION
CHAMPAIGN - URBANA WEATHER SUMMARY

May 1953

Date	Temperature (°F) Max.	Min.	Mean	Precipitation Amt.	Type	Wind Dir.	Speed	Sky Condition
1	79	50	65	.16	R	SSW	9	Pt. Cloudy
2	64	45	55	0		WSW	8	Pt. Cloudy
3	73	43	58	0		WSW	8	Clear
4	65	47	56	.T	L	NE	8	Cloudy
5	69	48	59	.16	RL	NE	7	Cloudy
6	65	45	55	0		SW	5	Pt. Cloudy
7	70	51	61	.43	RW	C	3	Cloudy
8	72	51	62	.T	R	SSW	4	Pt. Cloudy
9	80	53	67	0		SW	7	Clear
10	61	54	68	0		SE	10	Pt. Cloudy
11	77	60	69	0		SW	5	Pt. Cloudy
12	73	63	68	.T	R	SSE	6	Cloudy
13	66	40	53	.07	R	NNE	9	Cloudy
14	54	40	47	.05	R	E	5	Cloudy
15	68	49	59	0		SSE	3	Pt. Cloudy
16	64	54	59	.90	RWTRW	ESE	4	Cloudy
17	71	57	64	0		WSW	6	Cloudy
18	74	47	61	.T	R	C	3	Pt. Cloudy
19	74	49	62	0		NNE	4	Pt. Cloudy
20	80	51	66	0		SE	9	Pt. Cloudy
21	86	65	76	.19	TRWH	S	10	Pt. Cloudy
22	74	51	63	.09	TRWRW	ENE	7	Cloudy
23	71	44	58	.T	R	E	6	Clear
24	77	57	67	.09	R	E	6	Pt. Cloudy
25	88	67	78	0		WSW	8	Pt. Cloudy
26	89	75	82	0		N	8	Clear
27	75	47	61	0		ENE	7	Pt. Cloudy
28	76	52	64	0		SSE	6	Pt. Cloudy
29	90	54	72	0		WSW	8	Clear
30	92	68	80	0		W	9	Clear
31	92	69	81	0		NW	6	Clear

Monthly Mean or Total and Departure from Normal

	Temperature (°F) Max.	Min.	Mean	Precipitation Inches	Wind Dir.	Speed (mph)
Mean	75.1	53.1	64.5	1.94	E	6.5
Dep.	+3.1	+2.5	+3.2	-2.21		

Degree Days Total 113 (-13) Accumulate 5180 (-269)

Precipitation Code

R - Rain, S - Snow, L - Drizzle, E - Sleet, RW - Rainshower, TRW - Thundershower, H - Hail.

Sky Cover Code

0.0-0.3 - Clear; 0.4-0.7 - Partly Cloudy; 0.8-1.0 - Cloudy

TABLE AV. 7

STATE WATER SURVEY DIVISION
CHAMPAIGN - URBANA WEATHER SUMMARY

June 1953

Date	Temperature (°F) Max.	Min.	Mean	Precipitation Amt.	Type	Wind Dir.	Speed	Sky Condition
1	83	56	70			NE	6	Pt. Cloudy
2	81	48	65			E	3	Clear
3	85	58	72			SW	7	Clear
4	90	62	76			SW	9	Clear
5	90	68	79	.T	TRWRW	WSW	7	Pt. Cloudy
6	78	61	70	.12	RWTRW	NW	4	Cloudy
7	83	59	71	0		E	6	Pt. Cloudy
8	92	64	78	.62	TRW H	W	7	Pt. Cloudy
9	91	72	82	.T	TRW	E	4	Pt. Cloudy
10	89	68	79	0		NE	6	Pt. Cloudy
11	83	64	74	0		ESE	5	Pt. Cloudy
12	93	68	81	0		NW	4	Clear
13	85	69	77	.22	TRW	C	2	Cloudy
14	78	62	70	.17	TRW	NE	6	Pt. Cloudy
15	84	57	71	.06	RW	ESE	5	Clear
16	90	68	79	.02	RW	WSW	8	Clear
17	84	64	74	0		NNW	6	Clear
18	93	58	76	0		SE	5	Clear
19	102	72	87	0		SE	7	Clear
20	103	76	90	.T	R	SE	8	Clear
21	95	66	81	0		NW	5	Clear
22	96	67	82	.T	R	C	3	Pt. Cloudy
23	93	66	80	.T	TRW	N	5	Clear
24	98	65	82	0		ESE	7	Pt. Cloudy
25	89	70	80	.74	TRW	ESE	8	Cloudy
26	82	65	74	.83	TRW	C	4	Cloudy
27	90	66	78	.T	TRW	S	6	Clear
28	90	68	79	.14	TRW	WNW	5	Pt. Cloudy
29	92	72	82	0		WSW	3	Pt. Cloudy
30	93	73	83	0		SW	5	Pt. Cloudy

Monthly Mean or Total and Departure from Normal

	Temperature (°F) Max.	Min.	Mean	Precipitation Inches	Wind Dir.	Speed (mph)
Mean	89.1	65.1	77.4	2.92	SE	5.5
Dep.	+7.5	+5.0	+6.5	-1.06		

Precipitation Code

R - Rain, S - Snow, L - Drizzle, E - Sleet, RW - Rainshower, TRW - Thundershower, H - Hail.

Sky Cover Code

0.0-0.3 - Clear; 0.4-0.7 - Partly Cloudy; 0.8-1.0 - Cloudy

STAT

APPENDIX VI

COPIES OF TESTS USED DURING STUDY

Name _____ Date _____

This test is concerned with the ration items used in this experiment. Pairs of items are listed below. Circle the one item of each pair which you prefer. You must circle one in every pair.

1. Chocolate bar	Gum drops
2. Life savers	Meat bar
3. Gum drops	Cereal bar
4. Jelly bar	Chocolate bar
5. Cereal bar	Meat bar
6. Life savers	Jelly bar
7. Meat bar	Chocolate bar
8. Cereal bar	Jelly bar
9. Gum drops	Life savers
10. Jelly bar	Meat bar
11. Chocolate bar	Cereal bar
12. Jelly bar	Gum drops
13. Chocolate bar	Life savers
14. Meat bar	Gum drops
15. Life savers	Cereal bar

STAT

Name _____ Date _____

On this test you will find a number of personality traits. To the right of each trait you will find a pair of names. You are to circle the name of the person in each pair who in your opinion is better described by the trait. For example:

Honesty (Lincoln) Dillinger

(The circle indicates you believe Lincoln is more honest than Dillinger).

Intellectual ability	Sargent	Skigen
Tolerance	Lacey	Van Gelder
Friendliness	Skigen	May
Cooperation	Mendelsohn	Van Gelder
Honesty	Lacey	Sargent
Intellectual ability	Wogan	Kallhauge
Tolerance	Skigen	Adams
Friendliness	Mendelsohn	May
Cooperation	Lacey	Wogan
Honesty	May	Sargent
Intellectual ability	Skigen	Van Gelder
Tolerance	Kallhauge	May
Friendliness	Mendelsohn	Wogan
Cooperation	Van Gelder	Adams
Honesty	Kallhauge	Skigen
Intellectual ability	May	Lacey
Tolerance	Van Gelder	Kallhauge
Friendliness	Mendelsohn	Sargent
Cooperation	Wogan	Adams
Honesty	Van Gelder	May
Intellectual ability	Skigen	Wogan
Tolerance	Mendelsohn	Adams

Friendliness	Wogan	Sargent
Cooperation	Kallhauge	Mendelsohn
Honesty	Adams	Lacey
Intellectual ability	May	Wogan
Tolerance	Mendelsohn	Lacey
Friendliness	Adams	Kallhauge
Cooperation	Van Gelder	Sargent
Honesty	Skigen	Lacey
Intellectual ability	Adams	Sargent
Tolerance	Lacey	Kallhauge
Friendliness	Mendelsohn	Skigen
Cooperation	Kallhauge	Sargent
Honesty	Wogan	Van Gelder
Intellectual ability	May	Adams
Tolerance	Skigen	Sargent
Friendliness	Van Gelder	Lacey
Cooperation	May	Skigen
Honesty	Van Gelder	Mendelsohn
Intellectual ability	Sargent	Lacey
Tolerance	Kallhauge	Wogan
Friendliness	Adams	Skigen
Cooperation	May	Mendelsohn
Honesty	Wogan	Lacey
Intellectual ability	Sargent	May
Tolerance	Van Gelder	Skigen
Friendliness	May	Kallhauge
Cooperation	Wogan	Mendelsohn

STAT

Honesty	Adams	Van Gelder
Intellectual ability	Skigen	Kallhauge
Tolerance	Lacey	May
Friendliness	Kallhauge	Van Gelder
Cooperation	Sargent	Mendelsohn
Honesty	Adams	Wogan
Intellectual ability	May	Van Gelder
Tolerance	Wogan	Skigen
Friendliness	Adams	Mendelsohn
Cooperation	Sargent	Wogan
Honesty	Mendelsohn	Kallhauge
Intellectual ability	Lacey	Adams
Tolerance	Wogan	May
Friendliness	Lacey	Mendelsohn
Cooperation	Kallhauge	Adams
Honesty	Sargent	Van Gelder
Intellectual ability	Lacey	Skigen
Tolerance	Sargent	Adams
Friendliness	Kallhauge	Lacey
Cooperation	Skigen	Mendelsohn
Honesty	Sargent	Kallhauge
Intellectual ability	Van Gelder	Wogan
Tolerance	May	Adams
Friendliness	Sargent	Skigen
Cooperation	Lacey	Van Gelder
Honesty	Skigen	May
Intellectual ability	Mendelsohn	Van Gelder

Tolerance	Lacey	Sargent
Friendliness	Wogan	Kallhauge
Cooperation	Skigen	Adams
Honesty	Mendelsohn	May
Intellectual ability	Lacey	Wogan
Tolerance	May	Sargent
Friendliness	Skigen	Van Gelder
Cooperation	Kallhauge	May
Honesty	Mendelsohn	Wogan
Intellectual ability	Van Gelder	Adams
Tolerance	Kallhauge	Skigen
Friendliness	May	Lacey
Cooperation	Van Gelder	Kallhauge
Honesty	Mendelsohn	Sargent
Intellectual ability	Wogan	Adams
Tolerance	Van Gelder	May
Friendliness	Skigen	Wogan
Cooperation	Mendelsohn	Adams
Honesty	Wogan	Sargent
Intellectual ability	Kallhauge	Mendelsohn
Tolerance	Adams	Lacey
Friendliness	May	Wogan
Cooperation	Mendelsohn	Lacey
Honesty	Adams	Kallhauge
Intellectual ability	Van Gelder	Sargent
Tolerance	Skigen	Lacey

STAT

Friendliness	Adams	Sargent
Cooperation	Lacey	Kallhauge
Honesty	Mendelsohn	Skigen
Intellectual ability	Kallhauge	Sargent
Tolerance	Wogan	Van Gelder
Friendliness	Adams	May
Cooperation	Skigen	Sargent
Honesty	Van Gelder	Lacey
Intellectual ability	May	Skigen
Tolerance	Van Gelder	Mendelsohn
Friendliness	Sargent	Lacey
Cooperation	Kallhauge	Wogan
Honesty	Adams	Skigen
Intellectual ability	May	Mendelsohn
Tolerance	Wogan	Lacey
Friendliness	Sargent	May
Cooperation	Van Gelder	Skigen
Honesty	May	Kallhauge
Intellectual ability	Wogan	Mendelsohn
Tolerance	Adams	Van Gelder
Friendliness	Skigen	Kallhauge
Cooperation	Lacey	May
Honesty	Kallhauge	Van Gelder
Intellectual ability	Sargent	Mendelsohn
Tolerance	Adams	Wogan
Friendliness	May	Van Gelder

Cooperation	Wogan	Skigen
Honesty	Adams	Mendelsohn
Intellectual ability	Sargent	Wogan
Tolerance	Mendelsohn	Kallhauge
Friendliness	Lacey	Adams
Cooperation	Wogan	May
Honesty	Lacey	Mendelsohn
Intellectual ability	Kallhauge	Adams
Tolerance	Sargent	Van Gelder
Friendliness	Lacey	Skigen
Cooperation	Sargent	Adams
Honesty	Kallhauge	Lacey
Intellectual ability	Skigen	Mendelsohn
Tolerance	Sargent	Kallhauge
Friendliness	Van Gelder	Wogan
Cooperation	May	Adams
Honesty	Sargent	Skigen
Intellectual ability	Lacey	Van Gelder
Tolerance	Skigen	May
Friendliness	Mendelsohn	Van Gelder
Cooperation	Lacey	Sargent
Honesty	Wogan	Kallhauge
Intellectual ability	Skigen	
Tolerance	Mendelsohn	May
Friendliness	Lacey	Wogan
Cooperation	May	Sargent

STAT

Honesty	Skigen	Van Gelder
Intellectual ability	Kallhauge	May
Tolerance	Mendelsohn	Wogan
Friendliness	Van Gelder	Adams
Cooperation	Kallhauge	Skigen
Honesty	May	Lacey
Intellectual ability	Van Gelder	Kallhauge
Tolerance	Mendelsohn	Sargent
Friendliness	Wogan	Adams
Cooperation	Van Gelder	May
Honesty	Skigen	Wogan
Intellectual ability	Mendelsohn	Adams
Tolerance	Wogan	Sargent
Friendliness	Kallhauge	Mendelsohn
Cooperation	Adams	Lacey
Honesty	May	Wogan
Intellectual ability	Mendelsohn	Lacey
Tolerance	Adams	Kallhauge
Friendliness	Van Gelder	Sargent
Cooperation	Skigen	Lacey
Honesty	Adams	Sargent
Intellectual ability	Lacey	Kallhauge
Tolerance	Mendelsohn	Skigen
Friendliness	Kallhauge	Sargent
Cooperation	Wogan	Van Gelder
Honesty	Adams	May

INSTRUCTIONS

The purpose of this study is to measure the meanings of certain words to various people by having them judge each word against a series of descriptive scales. In taking this test, please judge the words on the basis of what they mean to you. Each numbered item presents a CONCEPT (such as DICTATOR) and a scale (such as high-low). You are to rate the concept on the seven-point scale indicated.

If you felt that the concept was very closely associated with one end of the scale, you might place your check-mark as follows:

DICTATOR up : : : : : : √ down

If you felt that the concept was quite closely related to one side of the scale, you might check as follows:

HOUSE straight : √ : : : : : crooked

If the concept seemed only slightly related to one side as opposed to the other, you might check as follows:

CLOUD easy : : √ : : : difficult

If you considered the scale completely irrelevant, or that both sides are equally associated, you would check the middle space on the scale:

TREE idealistic : : : √ : : : realistic

IMPORTANT: (1) Place your check-marks in the middle of spaces, not on the boundaries:

This	Not This
: √ :	√

(2) Never put more than one check-mark on each scale.
(3) Be sure you check each item - do not omit any.

Sometimes you may feel as though you have had the same item before on the test. On some tests there may be some repeated items. However, please do not look back and forth through the test. Also, do not try to remember how you marked similar items earlier in the test. Make each item a separate and independent judgment. Work at fairly high speed, without worrying or puzzling over individual items for long periods. It is your first impressions that we want.

Some of the items may seem irrelevant to you. It was necessary, in the design of this test, to match every concept with every scale at some place, and this is why some items seem irrelevant — so give the most judgment you can and move along.

Thank you very much for your cooperation.

STAT
STAT

Since this test is going to be given in several sessions, please print your name below for identification purposes.

DATE _____ NAME _____

Jelly Bar	large	:	:	:	:	:	:	small
Grades	strong	:	:	:	:	:	:	weak
Dr. Sargent	valuable	:	:	:	:	:	:	worthless
Chocolate Bar	deep	:	:	:	:	:	:	shallow
Adams	pleasant	:	:	:	:	:	:	unpleasant
May	empty	:	:	:	:	:	:	full
Military Service	relaxed	:	:	:	:	:	:	tense
Lacy	brave	:	:	:	:	:	:	cowardly
Cereal Bar	fast	:	:	:	:	:	:	slow
Cooperation	healthy	:	:	:	:	:	:	sick
Skigen	large	:	:	:	:	:	:	small
Gum Drops	strong	:	:	:	:	:	:	weak
Mendelsohn	valuable	:	:	:	:	:	:	worthless
Love	deep	:	:	:	:	:	:	shallow
Wogan	pleasant	:	:	:	:	:	:	unpleasant
Kallhauge	empty	:	:	:	:	:	:	full
Death	relaxed	:	:	:	:	:	:	tense
Van Gelder	brave	:	:	:	:	:	:	cowardly
Life Savers	fast	:	:	:	:	:	:	slow
Meat Bar	healthy	:	:	:	:	:	:	sick
Jelly Bar	strong	:	:	:	:	:	:	weak
Grades	valuable	:	:	:	:	:	:	worthless

Dr. Sargent	deep	:	:	:	:	:	:	shallow
Chocolate Bar	pleasant	:	:	:	:	:	:	unpleasant
Adams	empty	:	:	:	:	:	:	full
May	relaxed	:	:	:	:	:	:	tense
Military Service	brave	:	:	:	:	:	:	cowardly
Lacy	fast	:	:	:	:	:	:	slow
Cereal Bar	healthy	:	:	:	:	:	:	sick
Cooperation	large	:	:	:	:	:	:	small
Skigen	strong	:	:	:	:	:	:	weak
Gum Drops	valuable	:	:	:	:	:	:	worthless
Mendelsohn	deep	:	:	:	:	:	:	shallow
Love	pleasant	:	:	:	:	:	:	unpleasant
Wogan	empty	:	:	:	:	:	:	full
Kallhauge	relaxed	:	:	:	:	:	:	tense
Death	brave	:	:	:	:	:	:	cowardly
Van Gelder	fast	:	:	:	:	:	:	slow
Life Savers	healthy	:	:	:	:	:	:	sick
Meat Bar	large	:	:	:	:	:	:	small
Jelly Bar	valuable	:	:	:	:	:	:	worthless
Grades	deep	:	:	:	:	:	:	shallow
Dr. Sargent	pleasant	:	:	:	:	:	:	unpleasant
Chocolate Bar	empty	:	:	:	:	:	:	full
Adams	relaxed	:	:	:	:	:	:	tense
May	brave	:	:	:	:	:	:	cowardly
Military Service	fast	:	:	:	:	:	:	slow
Lacy	healthy	:	:	:	:	:	:	sick
Cereal Bar	large	:	:	:	:	:	:	small

STAT

Cooperation	strong	weak
Skigen	valuable	worthless
Gum Drops	deep	shallow
Mendelsohn	pleasant	unpleasant
Love	empty	full
Wogan	relaxed	tense
Kallhauge	brave	cowardly
Death	fast	slow
Van Gelder	healthy	sick
Life Savers	large	small
Meat Bar	strong	weak
Jelly Bar	deep	shallow
Grades	pleasant	unpleasant
Dr. Sargent	empty	full
Chocolate Bar	relaxed	tense
Adams	brave	cowardly
May	fast	slow
Military Service	healthy	sick
Lacy	large	small
Cereal Bar	strong	weak
Cooperation	valuable	worthless
Skigen	deep	shallow
Gum Drops	pleasant	unpleasant
Mendelsohn	empty	full
Love	relaxed	tense
Wogan	brave	cowardly
Kallhauge	fast	slow

Death	healthy	sick
Van Gelder	large	small
Life Savers	strong	weak
Meat Bar	valuable	worthless
Jelly Bar	pleasant	unpleasant
Grades	empty	full
Dr. Sargent	relaxed	tense
Chocolate Bar	brave	cowardly
Adams	fast	slow
May	healthy	sick
Military Service	large	small
Lacy	strong	weak
Cereal Bar	valuable	worthless
Cooperation	deep	shallow
Skigen	pleasant	unpleasant
Gum Drops	empty	full
Mendelsohn	relaxed	tense
Love	brave	cowardly
Wogan	fast	slow
Kallhauge	healthy	sick
Death	large	small
Van Gelder	strong	weak
Life Savers	valuable	worthless
Meat Bar	deep	shallow
Jelly Bar	empty	full
Grades	relaxed	tense
Dr. Sargent	brave	cowardly
Chocolate Bar	fast	slow

STAT

Adams
May
Military Service
Lacy
Cereal Bar
Cooperation
Skigen
Gum Drops
Mendelsohn
Love
Wogan
Kallhauge
Death
Van Gelder
Life Savers
Meat Bar
Jelly Bar
Grades
Dr. Sargent
Chocolate Bar
Adams
May
Military Service
Lacy
Cereal Bar
Cooperation

healthy___:___:___:___:___:___:___sick
large___:___:___:___:___:___:___small
strong___:___:___:___:___:___:___weak
valuable___:___:___:___:___:___:___worthless
deep___:___:___:___:___:___:___shallow
pleasant___:___:___:___:___:___:___unpleasant
empty___:___:___:___:___:___:___full
relaxed___:___:___:___:___:___:___tense
brave___:___:___:___:___:___:___cowardly
fast___:___:___:___:___:___:___slow
healthy___:___:___:___:___:___:___sick
large___:___:___:___:___:___:___small
strong___:___:___:___:___:___:___weak
valuable___:___:___:___:___:___:___worthless
deep___:___:___:___:___:___:___shallow
pleasant___:___:___:___:___:___:___unpleasant
relaxed___:___:___:___:___:___:___tense
brave___:___:___:___:___:___:___cowardly
fast___:___:___:___:___:___:___slow
healthy___:___:___:___:___:___:___sick
large___:___:___:___:___:___:___small
strong___:___:___:___:___:___:___weak
valuable___:___:___:___:___:___:___worthless
deep___:___:___:___:___:___:___shallow
pleasant___:___:___:___:___:___:___unpleasant
empty___:___:___:___:___:___:___full

Skigen
Gum Drops
Mendelsohn
Love
Wogan
Kallhauge
Death
Van Gelder
Life Savers
Meat Bar
Jelly Bar
Grades
Dr. Sargent
Chocolate Bar
Adams
May
Military Service
Lacy
Cereal Bar
Cooperation
Skigen
Gum Drops
Mendelsohn
Love
Wogan
Kallhauge

relaxed___:___:___:___:___:___:___tense
brave___:___:___:___:___:___:___cowardly
fast___:___:___:___:___:___:___slow
healthy___:___:___:___:___:___:___sick
large___:___:___:___:___:___:___small
strong___:___:___:___:___:___:___weak
valuable___:___:___:___:___:___:___worthless
deep___:___:___:___:___:___:___shallow
pleasant___:___:___:___:___:___:___unpleasant
empty___:___:___:___:___:___:___full
brave___:___:___:___:___:___:___cowardly
fast___:___:___:___:___:___:___slow
healthy___:___:___:___:___:___:___sick
large___:___:___:___:___:___:___small
strong___:___:___:___:___:___:___weak
valuable___:___:___:___:___:___:___worthless
deep___:___:___:___:___:___:___shallow
pleasant___:___:___:___:___:___:___unpleasant
empty___:___:___:___:___:___:___full
relaxed___:___:___:___:___:___:___tense
brave___:___:___:___:___:___:___cowardly
fast___:___:___:___:___:___:___slow
healthy___:___:___:___:___:___:___sick
large___:___:___:___:___:___:___small
strong___:___:___:___:___:___:___weak
valuable___:___:___:___:___:___:___worthless

STAT
STAT

Death	deep : : : : : : : shallow
Van Gelder	pleasant : : : : : : : unpleasant
Life Savers	empty : : : : : : : full
Meat Bar	relaxed : : : : : : : tense
Jelly Bar	fast : : : : : : : slow
Grades	healthy : : : : : : : sick
Dr. Sargent	large : : : : : : : small
Chocolate Bar	strong : : : : : : : weak
Adams	valuable : : : : : : : worthless
May	deep : : : : : : : shallow
Military Service	pleasant : : : : : : : unpleasant
Lacy	empty : : : : : : : full
Cereal Bar	relaxed : : : : : : : tense
Cooperation	brave : : : : : : : cowardly
Skigen	fast : : : : : : : slow
Gum Drops	healthy : : : : : : : sick
Mendelsohn	large : : : : : : : small
Love	strong : : : : : : : weak
Wogan	valuable : : : : : : : worthless
Kallhauge	deep : : : : : : : shallow
Death	pleasant : : : : : : : unpleasant
Van Gelder	empty : : : : : : : full
Life Savers	relaxed : : : : : : : tense
Meat Bar	brave : : : : : : : cowardly
Jelly Bar	healthy : : : : : : : sick
Grades	large : : : : : : : small
Dr. Sargent	strong : : : : : : : weak

Chocolate Bar	valuable : : : : : : : worthless
Adams	deep : : : : : : : shallow
May	pleasant : : : : : : : unpleasant
Military Service	empty : : : : : : : full
Lacy	relaxed : : : : : : : tense
Cereal Bar	brave : : : : : : : cowardly
Cooperation	fast : : : : : : : slow
Skigen	healthy : : : : : : : sick
Gum Drops	large : : : : : : : small
Mendelsohn	strong : : : : : : : weak
Love	valuable : : : : : : : worthless
Wogan	deep : : : : : : : shallow
Kallhauge	pleasant : : : : : : : unpleasant
Death	empty : : : : : : : full
Van Gelder	relaxed : : : : : : : tense
Life Savers	brave : : : : : : : cowardly
Meat Bar	fast : : : : : : : slow

STAT