ON THE

PHYSIOLOGICAL EFFECTS OF SEVERE AND PROTRACTED

MUSCULAR EXERCISE;

WITH SPECIAL

REFERENCE TO ITS INFLUENCE UPON THE EXCRETION OF NITROGEN.

BY

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PHYSIOLOGICAL EFFECTS OF SEVERE AND PROTRACTED MUSCULAR EXERCISE.

The Chemical Analyses were made under the direction of R. O. Doremus, M. D., Professor of Chemistry and Toxicology in the Bellevue Hospital Medical College, etc., etc., by Mr. Oscar Loew, Assistant to Prof. Doremus.

The Observations were made with the coöperation of J. C. Dalton, M. D., Professor of Physiology in the College of Physicians and Surgeons; and Alexander B. Mott, M. D., Professor of Surgical Anatomy; W. H. Van Buren, M. D., Professor of Principles of Surgery, etc.; Austin Flint, M. D., Professor of the Principles and Practice of Medicine; W. A. Hammond, M. D., Professor of Diseases of the Mind and Nervous System—all of the Bellevue Hospital Medical College.

PART I.

In May, 1870, I had an opportunity of examining the entire urine passed by Mr. Edward Payson Weston, the celebrated pedestrian, during the time occupied in accomplishing the extraordinary feat of walking one hundred miles in twenty-one hours and thirty-nine minutes. The urine on that occasion was accidentally passed into a single vessel, and had been undisturbed until it came into my possession. I had no means of obtaining any reliable scientific information with regard to the amount and character of the food taken during that time, nor had I obtained, for purposes of comparison, a specimen of the urine passed on the day before this remarkable muscular effort. It was several weeks, indeed, before I could get the urine of twenty-four hours of comparative repose; which I was forced to take as representing about the normal excretion. I simply took the material for scientific analysis as I could best obtain it, and published the results, with a statement of the facts, not at that time entertaining any definite hope of being able to repeat the investigations under more favorable conditions. I was, of course, well aware of the necessity of carefully estimating certain elements of the food, and of connecting the elimination of effete matters, particularly those containing nitrogen, with the matters ingested. Had I been sure of an opportunity of studying the effects upon excretion of excessive and prolonged muscular exertion, such as has since presented itself, my first experiments, of the unavoidable defects of which no one could be more sensible than myself, would never have been published. My first observations have been excluded in the present inquiry, on account of the imperfect data on which they were based; but I may anticipate my conclusions from these more complete experiments enough to state that the results have been essentially the same as those first obtained.

In the summer of 1870, Mr. Weston proposed to make an attempt to walk four hundred miles in five consecutive days, and, upon one of those days, to walk one hundred and twelve miles in twenty-four consecutive hours. He kindly offered to submit himself to any scientific observations that I might wish to undertake in connection with this effort. It is hardly necessary to say that this offer was gladly accepted; and I regarded it as a sacred duty to use every endeavor to make this occasion to the fullest extent useful to physiological science. The investigations to be made seemed to me of such importance, particularly in the present unsettled state of physiological opinion upon certain points connected with nutrition and disassimilation, that I asked the aid of certain of my friends, well known for their scientific attainments, in projecting and carrying out a series of experiments which should be as complete as possible.

The following gentlemen consented to lend to the proposed work the advantage of their scientific experience and judgment: Dr. R. Ogden Doremus, Professor of Chemistry in the Bellevue Hospital Medical College and the College of the City of New York; Dr. J. C. Dalton, Professor of Physiology in the College of Physicians and Surgeons; and Dr. W. H. Van Buren, Professor of the Principles of Surgery, etc.; Dr. Austin Flint, Professor of the Principles and Practice of Medicine; Dr. W. A. Hammond, Professor of Diseases of the Mind and Nervous System; and Dr. Alexander B. Mott, Professor of Surgical Anatomy—all of the Bellevue Hospital Medical College. Prof. Hammond, among his earliest contributions to science, made observations on the influence of exercise upon the elimination of urea, which have been fully confirmed by our researches in the present instance.[1]

At a meeting held some weeks before the walk, a definite plan of investigations was agreed upon. Prof. Doremus assumed the responsibility of all of the necessary chemical analyses, and I proposed to take charge myself of the remaining scientific work, and to superintend the records of diet, etc. The plan of operations agreed upon will be fully detailed further on, as an introduction to an account of our observations; but this may be anticipated at the outset by a few general statements.

It was proposed to make our observations for three distinct periods, viz.; first period, five days before the walk; second period, the five days of the walk; third period, five days after the walk. For the fifteen days during which Mr. Weston was to be under observation, it was proposed to have a trusty assistant with him every instant, day and night, who was to weigh his food and drink and make notes under the direction of one of our number. This was done by Mr. Thomas C. Doremus, Jr., who performed his arduous task in the most faithful and accurate manner. The urine and fæces were sent to the labora-

[1] HAMMOND, *The Relations existing between Urea and Uric Acid.—Physiological Memoirs*, Philadelphia, 1863, p. 9; from the *American Journal of the Medical Sciences*, January, 1855.

tory of Prof. Doremus, where they were analyzed under his direction by his able assistant, Mr. Oscar Loew. The results show the value of the immense amount of labor bestowed by Mr. Loew upon these analyses; a labor undertaken and carried out with a scientific enthusiasm which has added much to the value of our results. The necessary analyses of food were also made by Mr. Loew.

The material thus collected, with a complete record of the walk, finally passed into my hands for classification and analysis. Before a word of this report was written, the tables of food, composition of urine, fæces, etc., were calculated. This alone has been a labor of several weeks, and no pains has been spared to secure entire accuracy. The numerical calculations were all made by two or more different methods, so that it has seemed almost impossible that any error of importance should have been overlooked. Taking, as I have, the bare records and analyses made by Mr. Doremus and Mr. Loew, with entire ignorance of their probable results, the calculations proceeded steadily to their mathematical conclusions, which were only apparent at their actual completion.

In the preparation of this paper, I have attempted to present the scientific data in such a form as to be easily available as ascertained facts, to any who may not admit the interpretation I have put upon them.

It may serve to make the bearing of our observations more easily comprehended to give a succinct statement of the generally-received physiological views regarding certain of the points involved. In this I do not propose to analyze the literature of the subject, even for the past few years; and I desire especially to avoid controversial discussion. I do not intend to criticise the experiments of others or to point out their defects, except in so far as these defects may seem to be supplied by my more extended opportunities for investigations in particular directions.

Views of Physiologists with regard to the Influence of Exercise, Diet, etc., upon the Elimination of Nitrogenized Excrementitious Matters, chiefly Urea.

Following the brilliant researches of Lavoisier upon the chemical phenomena of respiration and their relations to animal heat, the theories of Liebig, who divided the food into two classes, plastic and calorific, were almost universally adopted by physiologists. Liebig advanced the view that those articles of food composed of carbon, hydrogen, and oxygen, were chiefly, if not entirely, useful in maintaining the animal temperature, by entering into combination with the oxygen of the inspired air, producing carbonic acid, water, and heat. He regarded the elements of food composed of carbon, hydrogen, oxygen, and nitrogen, as concerned chiefly, if not entirely, in repairing the waste of the nitrogenized portions of the living body, particularly the muscular tissue. Applying these views to muscular action, Liebig assumed that exercise was always attended with an increased activity in the destructive metamorphosis of the nitrogenized substance of the muscular tissue; and that this could be measured by the amount of urea excreted. The following quotation from one of his earlier works embraces the whole question:

"Boiled and roasted flesh is converted at once into blood; while the uric acid and urea are derived from the metamorphosed tissues. The quantity of these products increases with the rapidity of transformation in a given time, but bears no proportion to the amount of food taken in the same period. In a starving man, who is any way compelled to undergo severe and continued exertion, more urea is secreted than in the most highly-fed individual if in a state of rest."[1]

Again, Liebig makes the general statement that "the amount of tissue metamorphosis in a given time may be measured by the quantity of nitrogen in the urine."[2]

For many years, this view of the source of the nitrogenized excrementitious principles and the laws which regulate the activity of their production was received by physiologists almost without question. It was modified, however, a few years later, by the researches of Lehmann, who showed by a large number of observations on his own person that, other conditions being equal, the character and quantity of food modified very greatly

[1] LIEBIG, *Animal Chemistry, or Chemistry in its Applications to Physiology and Pathology*, London, 1843, p. 138.

[2] Ibid., p. 245.

the elimination of urea, as is seen by the following quotation:

"My experiments show that the amount of urea which is excreted is extremely dependent on the nature of the food which has been previously taken. On a purely animal diet, or on food very rich in nitrogen, there were often two-fifths more urea excreted than on a mixed diet; while, on a mixed diet, there was almost one-third more than on a purely vegetable diet; while, finally, on a non-nitrogenous diet, the amount of urea was less than half the quantity excreted during an ordinary mixed diet."[1] Lehmann further states, however, that, upon a uniform diet, the elimination of urea is increased by muscular exercise.

The views of Liebig, modified by the researches of Lehmann, were pretty generally accepted, up to 1866; notwithstanding that Bischoff had advanced experiments to prove that the elimination of nitrogen by the kidneys was regulated almost entirely by the amount of nitrogen in the ingesta.[2]

In 1866, Fick and Wislicenus published an account of experiments made in ascending one of the Alpine peaks, the Faulhorn, about 6,500 feet high. These experiments were undertaken with the view of showing that severe and prolonged muscular effort could be accomplished upon a non-nitrogenous diet. The two experimenters took no albuminoid food from mid-day on August 29th until seven P. M. of August 30th. The experiments proper began on the evening of the 29th, at a quarter-past six P. M., by a complete evacuation of the bladder. The urine from this time till ten minutes past five on the morning of the 30th (about eleven hours) was collected, and called the "night-urine." The ascent began at ten minutes past five and occupied eight hours and ten minutes. The urine passed during this period was collected as "work-urine." The urine for five hours and forty minutes after the ascent was

[1] LEHMANN, *Physiological Chemistry*, Philadelphia, 1855, vol. i., p. 150.

[2] BISCHOFF, *Der Harnstoff als Maas des Stoffwechsels*, Giessen, 1853. In 1860, these researches were considerably extended by Bischoff and Voit. BISCHOFF UND VOIT, *Die Gesetze der Ernährung des Fleischfressers*, Leipzig und Heidelberg, 1860.

collected as "after-work urine." The urine from seven P. M., August 30th, till half-past five A. M., August 31st, was collected and designated as "night-urine." The results of the examinations of these specimens in the two persons were nearly identical. The following is the estimate of the elimination of nitrogen per hour during the different periods: [1]

	Fick.	Wislicenus.
During the night, 29th to 30th	0.63 grammes.	0.61 grammes.
During the time of work	0.41 "	0.39 "
During rest after work	0.40 "	0.40 "
During the night, 30th to 31st	0.45 "	0.51 "

From these results, Fick and Wislicenus conclude that muscular exercise does not necessarily increase the elimination of nitrogen; that the substance of the muscle itself is consumed in insignificant quantity; and that the muscular system is a machine, consuming, in its work, not its own substance, but fuel, which is supplied by the food. The most efficient fuel Fick and Wislicenus consider to be non-nitrogenized food; the results of its consumption being force, or work, heat and carbonic acid. They adopt the view "that the substances, by the burning of which force is generated in the muscles, are not the albuminous constituents of the tissues, but non-nitrogenous substances, either as fats or hydrates of carbon."

"We might express this doctrine by the following simile: A bundle of muscle-fibres is a kind of machine consisting of albuminous material, just as a steam-engine is made of steel, iron, brass, etc. Now, as in the steam-engine coal is burnt in order to produce force, so, in the muscular machine, fats or hydrates of carbon are burnt for the same purpose. And in the same manner as the constructive material of the steam-engine (iron, etc.) is worn away and oxidized, the constructive material of the muscle is worn away, and this wearing away is the source of the nitrogenous constituents of the urine. This theory explains why, during muscular exertion, the excretion of the nitrogenous constituents of the urine is little or not all increased, while that of the carbonic acid is enormously aug-

[1] FICK AND WISLICENUS, *On the Origin of Muscular Power.—London, Edinburgh and Dublin Philosophical Magazine*, London, January–June, 1866, vol. xxxi., p. 492.

mented; for, in a steam-engine, moderately fired and ready for use, the oxidation of iron, etc., would go on tolerably equably, and would not be much increased by the more rapid firing necessary for working, but much more coal would be burnt when it was at work than when it was standing idle."[1]

I have made the above quotations from the paper of Fick and Wislicenus, for the reason that the theories therein advanced and the experiments reported have changed very materially the current of physiological opinion with regard to the origin of muscular force and the significance of the elimination of nitrogen. The question is not materially modified or advanced by the papers of Frankland[2] or of Haughton,[3] who sustain fully the views of Fick and Wislicenus, which are now adopted very largely, particularly in Germany and England.

The opposite view, that the elimination of nitrogen is to a great extent a measure of the waste of the nitrogenized elements of the tissues, and that this is increased by exercise, is substantially the one advanced by Liebig. Almost all observers who have experimented upon the influence of exercise upon the elimination of urea, under an ordinary diet, have found its excretion markedly increased. Among the earliest of these are the observations of Hammond, to which reference has already been made. In 1867, experiments were made by Parkes upon two soldiers, with the view of controlling the experiments of Fick and Wislicenus by observations upon a more extended scale.[4] These experiments failed to confirm those of Fick and Wislicenus. They were continued for a period of eighteen days, and certainly seemed to show an increase in the urea, attributable to muscular exercise. The extraordinary exercise taken was a walk of 23.70 miles on one

[1] *Loc. cit.*, p. 501.

[2] FRANKLAND, *On the Origin of Muscular Power.—London, Edinburgh and Dublin Philosophical Magazine*, London, July—December, 1866, vol. xxxii., p. 182, *et seq.*

[3] HAUGHTON, *Address on the Relation of Food to Work done by the Body, and its Bearing upon Medical Practice.—The Lancet*, London, August 15, August 22, and August 29, 1868.

[4] PARKES, *On the Elimination of Nitrogen by the Kidneys and Intestines, during Rest and Exercise, on a Diet without Nitrogen.—Proceedings of the Royal Society*, London, 1867, vol. xv., No. 89, p. 339, *et seq.*

day, and 32.78 miles on the day following. During these two days, on an exclusively non-nitrogenized diet, the elimination of nitrogen was slightly increased over a period of two days of rest and non-nitrogenized diet. In an analysis of a recent course of lectures delivered by Dr. Parkes, at the College of Physicians, London, it appears that he is disposed to take a view of the subject between the two extremes, viz.; that the muscular system is able to accomplish work by the consumption of non-nitrogenous food; that exercise does, however, slightly increase the elimination of urea, and that during exercise a small portion of the muscular substance is consumed; but he holds that the variations in the quantity of nitrogen eliminated are almost entirely dependent upon the amount of nitrogen contained in the food.[1]

One desirous of consulting further the literature of this interesting question will find, in a recent article by Liebig, a full discussion of the subject of the source of muscular power from his own point of view.[2] He analyzes very fully the experiments of Parkes, and finds in the results fresh testimony in favor of his view, that the increase in the elimination of nitrogen as a consequence of muscular exercise is not limited to the period of exertion, but continues for some time after. On the other hand, Voit has lately published a most elaborate paper reviewing the publications on this question that have appeared for the last twenty-five years.[3] Neither of these papers adds to the sum of physiological knowledge by the contribution of new experimental facts; but they are interesting, as expressing the arguments upon two opposite sides, and they illustrate the necessity of new observations, in which some of the important omissions in the experiments hitherto made may be supplied.

[1] *Abstract of the Croonian Lectures delivered at the College of Physicians by Dr. Parkes.—Medical Times and Gazette*, London, March 15, 1871, p. 348.

[2] Liebig, *The Source of Muscular Power.—The Pharmaceutical Journal and Transactions*, London, 1870, Third Series, part ii., p. 161, and part iii., pp. 181, 201, 221.

[3] Voit, *Ueber die Entwicklung der Lehre von der Quelle der Muskelkraft und einiger Theile der Ernährung seit 25 Jahren.—Zeitschrift für Biologie*, München, 1870, Bd. vi., S. 305, *et seq.*

Plan of the Investigations and the Processes employed.

A few weeks before Mr. Weston put himself under our observation, he was made to undergo a thorough physical examination at the hands of Prof. Austin Flint, and his urine was examined by myself. The result showed that Mr. Weston was in perfect health, at least as far as could be determined by any ordinary physical examination. This examination was made in order to ascertain whether or not there existed any physical reason why it would be unsafe for Mr. Weston to undertake his proposed task.

Having ascertained that Mr. Weston was in perfect health, he was invited to be present at a meeting of scientific gentlemen, for the purpose of fixing upon a definite plan of investigation. At this meeting were present, Profs. Doremus, Dalton, Van Buren, Flint, Hammond, and myself. Prof. Mott, who rendered us most valuable assistance during the walk, was not present at that meeting. Mr. Weston was here subjected to another examination with regard to his physical condition, which was found to be perfect.

As the result of our deliberations at this meeting, it was decided to confine our investigations within limits that would render it possible to complete them accurately and satisfactorily; the fear being that, in attempting to do too much, the value of our results might be impaired. It was also deemed proper to take the position that we would under no circumstances interfere with Mr. Weston's diet, training, or manner of making the walk, simply observing the facts according to our plan. This idea was fully carried out. Throughout the entire fifteen days during which Mr. Weston was under observation, he acted in every thing according to his own judgment; and the walk was made without any advice or interference on the part of any of the scientific gentlemen engaged in the investigations.

In collecting our material, it was determined to note the following points:

1. To take our observations during three periods, viz.; a first period, five days before the walk; the second, the five days of the walk; and the third, five days after the walk. Inasmuch as we proposed to assume the entire responsibility

of the accuracy of all the facts noted, it was determined to place Mr. Weston in the hands of Mr. Thomas C. Doremus, Jr., son of Prof. Doremus, who was not to leave him, night or day, without notifying the one in charge of the investigations. This was done. Mr. Doremus was actually with Mr. Weston, night and day, for the fifteen days, except on two occasions. On one day, for a few hours, Mr. Doremus' place was supplied by Mr. Loew, assistant to Prof. Doremus, who was engaged in making the chemical analyses. On another occasion, Mr. Doremus was relieved by myself for about four hours. During the walk, Prof. Mott, Prof. Doremus, and myself, one or all of us, were constantly present at the rink. Mr. Doremus was with Mr. Weston almost constantly at this time, but he occasionally slept in the building, when Mr. Weston was walking at night, leaving him in charge of one of us. It is necessary to make these statements, in view of the extraordinary character of our results, to show that nothing is taken as a fact to work upon, unless observed by ourselves or our assistants. I desire again to commend the fidelity with which Mr. Doremus executed that part of our plan intrusted to him, though, as is evident, it involved an immense amount of fatigue.

2. To take every day, as nearly as possible at the same hour and under the same conditions, the naked weight, pulse, respirations, and temperature.

3. To note accurately the weight of every separate article taken as food or drink. This was done for two purposes: to note the ingesta and excreta, with reference to the weight of the body; and to have all the articles of food separately weighed, so as to estimate the daily consumption of nitrogen.

4. To note the amount of exercise taken each day, in the first period, before the walk, and in the third period after the walk, and also to note any thing unusual with reference to his general condition.

5. To collect the entire urine of the twenty-four hours, day by day, for the purpose of subjecting it to chemical and microscopical examination. As Mr. Weston proposed to arrange in his walk of five days that the time should expire a few minutes after midnight, the twenty-four hours for collect-

ing the urine were calculated from midnight to midnight. It was also determined to collect and weigh the fæces.

In the execution of the above plan, I assumed the responsibility of superintending the records, except the notes of the chemical analyses, and of making microscopical examinations of the urinary sediments. Prof. Doremus assumed the responsibility of the chemical analyses. As far as the general records are concerned, I have no hesitation in testifying to their entire accuracy. It is fortunate that no accident happened, such as the breaking of a bottle or a glass, and the only error was in taking the weight on November 23d, the third day of the walk. Prof. Doremus is equally satisfied with regard to the chemical analyses, made by his assistant, Mr. Oscar Loew.

The details of the plan as it was carried out are as follows:

Mr. Doremus, Mr. Loew, and myself, were each provided with a note-book. My own note-book was for recording the microscopical examinations of the urinary sediments.

The following directions were written in the note-book given to Mr. Doremus:

At every meal, weigh the food and drink in the following manner:

Put the meat on a separate plate, and weigh the plate before and after eating. Note the loss of weight, which will give the quantity actually consumed. Mr. Weston does not intend to eat much fat, but expects to get his fat from butter. When he eats fat it is to be noted.

Put each vegetable on a separate plate and determine the quantity consumed, in the same way as for the meat.

Estimate the bread in the same way as the meat and vegetables.

Take a known weight of butter and weigh each night to ascertain the quantity taken during the day. It will be sufficient to determine in this way the quantity of butter consumed in the twenty-four hours.

Estimate the quantity of sugar taken, in the same way as the butter.

Note the number of eggs taken, and see that they are entirely consumed.

Measure the water taken, by fluidounces, and always carry a graduated glass for Mr. Weston to drink from, so that the amount shall be estimated exactly.

Measure the coffee, tea, and any other liquids taken, in the same way, and note especially the quantity of milk used.

Each night, just before Mr. Weston goes to bed, take the weight of the body, naked, the temperature under the tongue, the pulse and respirations, and note the time when the above-mentioned conditions are taken. The pulse is always to be counted sitting. The respirations are to be taken in the same position, when Mr. Weston's attention is diverted and when he is perfectly tranquil.

Note the exercise, miles walked, time, etc., for each twenty-four hours.

Collect all the urine for each twenty-four hours. Send six fluidounces to me for microscopical examination, and send the remainder to the chemical laboratory for quantitative analysis. Before any of the urine is sent, mix the whole for the twenty-four hours, and note on the bottle sent to the chemical laboratory the amount taken out for microscopical examination, so that the chemist may take that into account in his record of the entire quantity.

Collect the fæces and send them each day to the chemical laboratory.

At the end of each record for the day, note the general condition of health and feelings and any unusual circumstance that may have occurred during the day affecting the physiological conditions.

Note each fact instantly, leaving nothing to the memory. Read these directions carefully every night before closing the record for the day, and supply at once any omissions.

The following directions were written in the note-book given to Mr. Loew:

Measure the entire quantity of urine in the twenty-four hours.

Note the odor, color, reaction, and specific gravity.

Note the presence or absence of albumen and sugar.

Ascertain the proportions of various constituents of the urine, according to directions received from Prof. Doremus.

Be exceedingly careful to note each day accurately from midnight to midnight.

The weight was taken each night, generally in my presence, by Mr. Doremus, as near midnight as practicable, upon new platform-scales, weighing accurately to a quarter of a pound, kindly furnished by Messrs. Fairbanks & Co., of New York. The food was weighed upon a new balance, likewise furnished by Messrs. Fairbanks & Co., weighing accurately to $\frac{1}{64}$ of an ounce. These balances were selected on account of the well-known accuracy of the makers, and for their availability for rapid weighing, inasmuch as it was desirable to annoy Mr. Weston as little as possible, particularly in giving him his weighed food. The pulse, respirations, and temperature, were noted by myself, except on the evening of November 16th, when they were noted by Prof. Dalton. The temperature was taken under the tongue with a maximum thermometer, "Celsius, Berlin," graduated to $\frac{1}{10}$ of a degree, Centigrade.

The weight of the food was taken in the manner indicated. The liquids were measured in a graduated glass, as a matter of convenience; but their actual weight was calculated in the final tables.

Having taken the actual weight of each article of food, it was desired to ascertain the amount of nitrogen in the ingesta. After consulting carefully all the works at my command giving analyses of the different articles of food, I compiled the following table from the admirable treatise on alimentation, by Payen. It was at first thought desirable to subject specimens of each article to ultimate analysis for nitrogen; but the conditions under which the observations were carried out seemed to render the estimates of Payen even more useful. It was assumed at the outset that we were not to interfere with the diet in any way, noting only the articles taken. Mr. Weston's food was taken at several different places, and was prepared by different persons; and it would have been impossible to have analyzed actual specimens of each article. In view of this fact, it seemed probable that the variations from our analyses, should we have made them, would have been as considerable as the variations from the average estimates given by Payen. It has been ascertained, also, that the flesh of different animals presents but a small fraction of a percentage of difference in the nitrogen. All the meats, therefore, are classed together in the table, and are assimilated to the composition of cooked beef, which contains about 3.5 per cent. of nitrogen.[1] No estimate could be found of the proportion of nitrogen in the beef-essence, head-cheese, or oatmeal-gruel; and these articles were analyzed for nitrogen by Mr. Oscar Loew, by the ordinary method, viz.; treating the dry residue after evaporation with soda-lime, and determining the nitrogen as ammonio-chloride of platinum, reducing the metallic platinum by heat. The estimates of the proportion of nitrogen in the food were therefore approximative; but the percentage that might properly be allowed for error would be very slight. Even if this should be taken at the almost impossible figure of ten per cent., it would not modify the results. The advantage of experimenting upon a normal and unrestricted diet seems to me to more than compensate for the necessarily approximative estimates of the amount of nitrogen consumed.

Proportions of Nitrogen per Hundred Parts.

Article.	Nitrogen.	Authority.
Beef, Mutton, Chicken, Turkey, Fish	3.50	Payen, p. 488. This is the approximative estimate for cooked beef.
Eggs	1.90	Payen, p. 488.
Beef-essence	0.87	O. Loew (actual analysis).
Head-cheese	2.24	do. do.
Milk	0.66	Payen, p. 488.
Custard	1.28	Average of milk and eggs.
Ice-cream	1.28	do. do.
Cream-cakes	1.28	do. do.
Oysters	2.13	Payen, p. 489.
Cheese	4.12	do. do.
Bread (includes corn-cakes, cake, crackers, and bread-pudding)	1.08	Payen, p. 490.
Rice-pudding (rice and custard)	1.18	do. do.; Rice, p. 108.
Oatmeal-gruel	0.086	O. Loew (actual analysis).

[1] PAYEN, *Précis theorique et pratique des substances alimentaires*, Paris, 1865, p. 488, *et seq.*

Article.	Nitrogen.	Authority.
Potatoes	0.33	Payen, p. 490.
Figs	0.92	do. do.
Butter	0.64	do. do.
Coffee	0.11	do. do.
Tea	0.02	do. do.
Tomatoes	These articles contain no nitrogen, or merely a trace which may be disregarded.	
Cranberries		
Cauliflower		
Celery		
Lettuce		
Tomato-soup		
Tomato-catsup		
Grapes		
Apples		
Citron		
Preserves		
Sweet pickles		
Sugar		
Lemonade		
Molasses-and-water		
Vinegar		
Salt		
Pepper		
Bicarbonate of potash		

The urine of each twenty-four hours was carefully collected in a large, glass-stoppered bottle, and was analyzed by Mr. Loew, by the following methods:

The specific gravity was always determined by actual weight.

The urea was estimated by Liebig's volumetric process. In this, a single specimen of urine was used for estimating both chloride of sodium and urea. The chloride of sodium was determined first, and afterward the urea was determined with a different mercurial solution. This was done to avoid confusion and possible mistake in the readings of the burettes.

The uric acid was determined by weight; concentrating the urine, treating it for twelve hours with nitric acid, and collecting the crystals of uric acid.

The phosphoric acid was determined by weight, converting the phosphates into $2MgO,PO_5$.

The sulphuric acid was determined by weight, converting the sulphates into BaO,SO_3.

The examination of the urinary sediments was made by myself with a $\frac{1}{8}$ inch objective, allowing the specimen to stand about twelve hours.

The fæces were passed directly into clean glass vessels provided with air-tight glass covers, and weighed. The nitrogen of the fæces was estimated by the soda-lime and platinum process.

Physiological History of Mr. Weston for the Fifteen Days during which he was under Observation.

The fifteen days during which Mr. Weston was under observation were divided into three periods of five days each. During the first period of five days, he took very moderate exercise, and assumed to be "training" for the walk, though he did not pursue the system generally adopted in training for efforts of endurance. The second period embraces the five days of the walk. The third period of five days after the walk was one of almost absolute rest. During the entire fifteen days, he abstained altogether from alcoholic beverages. Though not what is called a total abstainer, Mr. Weston is not an habitual drinker. He occasionally takes a glass of ale or wine, but this is rare. During the first two periods, Mr. Weston did not smoke. He smoked from five to seven cigars daily during the third period of five days. In the records of food taken, the time of eating is stated, but I have not thought it necessary to extend the tables by giving a separate account of each meal, and shall generally give in a single table the entire quantity consumed in the twenty-four hours.

At the time of making the walk, Mr. Weston was thirty-one years and eight months old. His height is five feet and seven inches. His weight, naked, is from one hundred and twenty to one hundred and twenty-five pounds. He has never had any serious illness, with the exception of what he describes as vertigo and rather serious brain-symptoms after attempting a walk when he was suffering from a cold and headache. This occurred in the summer of 1870. He does not know that he has any hereditary tendency to disease. His physical conformation is interesting, in view of his immense powers of endurance.

His general build is slight, and the parts above the waist are very light. The bones of the chest and upper extremities are small, and the muscles are but little developed. The pelvis is unusually broad for a male, and the lower extremities are so formed that there is a considerable space between the thighs from the knees to the perinæum. This conformation is peculiarly fortunate, as it gives immunity from chafing, which is one of the greatest sources of annoyance to pedestrians. The lower extremities are remarkable for the unusual development of the muscles that move the thighs upon the pelvis. In walking, it is observed that Mr. Weston makes great use of these muscles, and uses the muscles of the leg very little. The calf of the leg is small; much smaller than one would expect to see in a pedestrian.

A noticeable peculiarity about the muscles of the thighs and legs is that they never become hard, or what is technically called "fine." They were quite soft before the walk, and at all times during the walk they were in the same condition. It was very remarkable that, after the third day, when Mr. Weston had walked within the twenty-four hours ninety-two miles, the muscles were as soft as ever. It has seemed to me that this peculiarity of the muscles is advantageous. When the muscles are very hard from thorough training, prolonged exertion is apt to produce cramps, due, perhaps, to exaggeration of the normal muscular irritability. This is also a difficulty experienced by pedestrians. In the case of Mr. Weston, the movements were always free, and, according to his statements, he was never much fatigued. Only once during the five days of the walk did he say that he was "leg-weary." What he complained of most was want of sleep, and, at one time, vertigo. The conformation of the feet is perfect; the toes are straight, the instep is high, and the heel is very long, giving a remarkable leverage for the tendo Achillis. The heel does not project, as in the negro, but the tendo Achillis passes straight to the calf of the leg.

The nervous element has seemed to me very important in the tasks accomplished by Mr. Weston. In walking, his pluck is extraordinary. On the fourth day of the walk,* having made on the first day, eighty miles, on the second, forty-eight miles, and on the third, ninety-two miles, he kept on the track after having walked over fifty miles, until his vertigo became so great that he could not see to turn the corners. He was forced from this cause to abandon all hope of making four hundred miles in five days; but on the fifth day, he appeared again at 10 A. M., and walked over forty miles. While walking, however, Mr. Weston was excessively sensitive, and was disturbed and annoyed by the slightest things. I am confident that he could accomplish more if he were properly prepared by training, and were cared for during his walks by a competent professional trainer.

First Period, Five Days before the Walk.

At midnight, November 15th, the observations were begun. At forty minutes past twelve, his general condition was as follows:

Weight (naked)...............	120.5 lbs. (54k. 655 grammes).
Temperature under the tongue,.........	98.6° (37° C.)
Pulse (sitting and perfectly tranquil)..............	64.
Respirations..................................	19.

Immediately after this examination, Mr. Weston went to bed.

November 16th, First Day.

Mr. Weston slept well during the night, and rose in good health and spirits at 8.15 A. M. He felt well the entire day; took his breakfast at 9.15 A. M.; dinner at 1.10 P. M.; and supper at 7.55 P. M. He walked during the day about fifteen miles. Though feeling well, he was worried and anxious about the business arrangements for his walk. He did not go to bed until 2.35 A. M., November 17th. He slept, during the twenty-four hours, seven hours and thirty minutes.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Beefsteak	12.25	187.58
Mutton-chops	3.00	45.94
Eggs	2.76	22.94
Milk	7.21	20.82
Bread	9.88	47.48
Potatoes	8.25	11.99
Butter	2.12	5.94
Sugar	1.78	00.00
Coffee	35.60	17.13
Tea	16.03	1.40
Water	24.00	00.00
Salt	0.09	00.00
Pepper	0.02	00.00
	122.99	361.22
	(3,492.17 grammes.)	(23.404 grammes.)

Total ingesta......... (7 lbs., 10 $\frac{99}{100}$ oz.)
Liquids.............. (5 lbs., 2 $\frac{84}{100}$ oz.)

Analyses of Excretions of Twenty-four Hours.

URINE.

Quantity	39.55 fl ℥ (1,170.0 c.c.)			
Specific gravity	1024.0			
Urea	650.08	grains,	42.120	grammes.
Nitrogen in urea	303.37	"	19.656	"
Uric acid	3.55	"	0.230	"
Phosphoric acid	51.46	"	3.334	"
Sulphuric acid	38.37	"	2.486	"
Chloride of sodium	195.02	"	12.636	"

This urine presented a light flocculent sediment, which contained a large number of octahedra of the oxalate of lime.

FÆCES.

Quantity	3.70 oz. av.	105.0	grammes.
Nitrogen	19.89 grains,	1.289	"
Nitrogen in urea and fæces combined	323.26 "	20.945	"

Nitrogen of urea and fæces per 100 parts of nitrogen of food..89.49 parts.
Uric acid per 100 parts of urea.......................... 0.538 "

10.30 P. M.
- Weight (naked)..........120.5 lbs. (54 k. 655 grammes.)
- Temperature under the tongue.......... 99.7° (37.° C.)
- Pulse, full and soft..................... 75.
- Respirations.......................... 20.

November 17th, Second Day.

After going to bed at 2.35 A. M., Mr. Weston rose at 8.45 A. M., and said that he felt well, but had not slept long enough. He had a little headache in the middle of the day, which continued until evening. He took breakfast at 9.40 A. M.; dinner at 2.30 P. M.; and supper at 7.40 P. M. He walked during the day about five miles. He was still worried about his arrangements for the walk. He went to bed at 11.30 P. M. He slept, during the twenty-four hours, six hours and forty minutes.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Beefsteak	5.25	80.39
Roast beef	5.25	80.39
Eggs	4.14	34.41
Milk	4.63	13.37
Bread	8.50	40.16
Potatoes	10.00	14.44
Tomatoes (stewed)	7.00	00.00
Butter	2.95	8.26
Sugar	1.25	00.00
Coffee	32.32	15.53
Tea	16.03	1.40
Water	8.00	00.00
Salt	0.02	00.00
Pepper	0.09	00.00
	105.43	288.35
	(2,987.92 grammes.)	(18.682 grammes.)

Total ingesta......... (6 lbs., 9 $\frac{43}{100}$ oz.)
Liquids............. (3 lbs., 12 $\frac{98}{100}$ oz.)

Analyses of Excretions of Twenty-four Hours.

URINE.

Quantity	38.03 fl ℥ (1125.0 c.c.)			
Specific gravity	1024.4			
Urea	590.35	grains,	38.250	grammes.
Nitrogen in urea	275.50	"	16.517	"
Uric acid	4.03	"	0.261	"
Phosphoric acid	44.08	"	2.921	"
Sulphuric acid	40.92	"	2.651	"
Chloride of sodium	158.00	"	10.237	"

The sediment was the same as on November 16th, but the octahedra of the oxalate of lime were more numerous.

FÆCES.

Quantity	4.78 oz. av.	135.5 grammes.
Nitrogen	25.68 grains,	1.664 "
Nitrogen in urea and fæces combined	301.18 "	18.181 "

Nitrogen of urea and fæces per 100 parts of nitrogen of food . 104.45 parts.
Uric acid per 100 parts of urea .... 0.683 "

11.20 P. M.	Weight (naked)	121.25 lbs. (55 kilos.)
	Temperature under the tongue	98.4° (36.9° C.)
	Pulse	73.
	Respirations	20.

November 18*th*, *Third Day*.

Mr. Weston rose at 9 A. M.; took his breakfast at 9.50 A. M.; dinner at 2.15 A. M.; and supper at 7.35 P. M. He said he felt "splendidly" all day. He wrote about seven hours, and walked about five miles. He was very cheerful all day, and went to bed at 12.20 A. M., November 19th. He slept, during the twenty-four hours, nine hours.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Beefsteak	10.37	158.79
Eggs	2.76	22.94
Milk	7.21	20.82
Bread	7.75	36.62
Potatoes	5.13	7.41
Butter	3.13	8.76
Sugar	1.75	00.00
Coffee	32.32	15.53
Tea	16.03	1.40
Salt	0.09	00.00
Pepper	0.02	00.00
	86.56	272.27
	(2,453.67 grammes.)	(17.641 grammes.)

Total ingesta .... (5 lbs., 6 $\frac{56}{100}$ oz.)
Liquids .... (3 lbs., 7 $\frac{56}{100}$ oz.)

Analyses of Excretions of Twenty-four Hours.

URINE.

Quantity	46.15 fl ℥ (1,365.0 c.c.)			
Specific gravity	1023.1			
Urea	653.08	grains,	42.315	grammes.
Nitrogen in urea	304.77	"	19.747	"
Uric acid	0.94	"	0.061	"
Phosphoric acid	45.14	"	2.925	"
Sulphuric acid	38.86	"	2.518	"
Chloride of sodium	191.70	"	12.421	"

There was a rather light, cloudy sediment, which contained a little mucus, and a very few small octahedra of the oxalate of lime.

FÆCES.

Quantity	4.76 oz. av.	135.0	grammes.
Nitrogen	25.59 grains,	1.658	"
Nitrogen in urea and fæces combined	330.36 "	21.405	"

Nitrogen of urea and fæces per 100 parts of nitrogen of food . . 121.30 parts.
Uric acid per 100 parts of urea . . . . . . 0.144 "

11.55 P. M.	Weight (naked)	120 lbs. (54 k. 432 grammes.)
	Temperature under the tongue	98° (36.7° C.)
	Pulse	71.
	Respirations	20.

November 19th, Fourth Day.

Mr. Weston rose at 8.35 A. M., feeling as well as possible; took breakfast at 9 A. M.; dinner at 4.45 P. M.; and supper at 10.45 P. M. He said he felt "splendidly" all day. He walked during the day about fifteen miles, was very cheerful, and went to bed at 12.45 A. M., November 20th. He slept, during the twenty-four hours, seven hours and fifteen minutes.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Beefsteak	4.25	65.08
Mutton-chops	4.88	74.72
Roast beef	4.88	74.72
Eggs	4.14	34.41
Milk	4.38	12.65
Bread	10.25	48.43

	Oz. Av.	Nitrogen, in grains.
Potatoes	0.88	1.27
Butter	2.43	6.80
Sugar	1.61	00.00
Coffee	32.32	15.53
Tea	16.03	1.40
Salt	0.09	00.00
Pepper	0.05	00.00
	86.19	335.01
	(2,443.19 grammes.)	(21.706 grammes.)

Total ingesta............ (5 lbs., $6\frac{19}{100}$ oz.)
Liquids.................. (4 lbs., $4\frac{73}{100}$ oz.)

Analyses of Excretions of Twenty-four Hours.

URINE.

Quantity	32.45 fl ℥		(960.0 c.c.)	
Specific gravity	1027.6.			
Urea	607.55	grains,	39.365	grammes.
Nitrogen in urea	283.52	"	18.370	"
Uric acid	1.06	"	0.069	"
Phosphoric acid	67.00	"	4.341	"
Sulphuric acid	51.50	"	3.337	"
Chloride of sodium	106.68	"	6.912	"

This urine presented a copious, fawn-colored sediment, which cleared up with gentle heat. It contained the amorphous urates, with a large number of octahedra of the oxalate of lime.

FÆCES.

Quantity	3.17 oz. av.	90.0	grammes.
Nitrogen	17.05 grains,	1.105	"

Nitrogen in urea and fæces combined....300.57 grains, 19.475 grammes.

Nitrogen of urea and fæces per 100 parts of nitrogen of food..89.75 parts.
Uric acid per 100 parts of urea.............................. 0.174 "

Weight (naked), taken at 12.35 A. M., November 20th, 118.5 (53 k. 745 grammes).

11.55 P. M.	Temperature under the tongue	99.1° (37.3° C.
	Pulse	78.
	Respirations	23.

November 20th, Fifth Day.

Mr. Weston rose at 10.45 A. M., feeling remarkably well. He took breakfast at 11.30 A. M.; dinner at 5.55 P. M.; and supper at 11.15 P. M. He said he felt "splendidly" all day.

He walked about one mile during the day. He started on his great walk at 12.15 A. M., November 21st. He slept, during the twenty-four hours, ten hours.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Beefsteak	18.25	279.45
Eggs	6.90	57.35
Milk	11.33	32.71
Bread	8.88	41.96
Potatoes	3.00	4.33
Butter	2.75	7.70
Sugar	1.75	00.00
Coffee	32.32	15.53
Tea	16.03	1.40
Salt	0.08	00.00
Pepper	0.05	00.00
	101.34	440.43
	(2,872.63 grammes.)	(28.536 grammes.)

Total ingesta............ (6 lbs., $5\frac{34}{100}$ oz.)
Liquids .... (3 lbs., $11\frac{68}{100}$ oz.)

Analyses of Excretions of Twenty-four Hours.

URINE.

Quantity	34.00 fl ℥.	(1,050.0 c.c.)		
Specific gravity	1025.2.			
Urea	640.13	grains,	41.475	grammes.
Nitrogen in urea	298.73	"	19.355	"
Uric acid	1.73	"	0.112	"
Phosphoric acid	43.01	"	2.787	"
Sulphuric acid	38.18	"	2.474	"
Chloride of sodium	145.85	"	9.450	"

This specimen of urine presented rather a faint, cloudy sediment, which contained a large number of octahedra of the oxalate of lime.

FÆCES.

Quantity	3.97 oz. av.	112.5	grammes.
Nitrogen	21.33 grains,	1.382	"

Nitrogen in urea and fæces combined......320.06 grains, 20.737 grammes.

Nitrogen of urea and fæces per 100 parts of nitrogen of food. 72.67 parts.
Uric acid per 100 parts of urea.............................. 0.270 "

11.45 P. M.	Weight (naked)	119.2 lbs. (54 k. 62 grammes.
	Temperature under the tongue	99.5° (37.5°C.)
	Pulse	93.
	Respirations	25.

Second Period.—Five Days of the Walk.

The walk proposed by Mr. Weston took place in an immense building of corrugated iron, known as the "Empire Skating Rink," on Third Avenue, near Sixty-fourth Street. This building is oblong, measuring 170 by 350 feet. A track made of boards covered with dirt and fine shavings was laid out in the form of a parallelogram. This track was measured by Mr. Joseph L. T. Smith, surveyor, in the presence of Prof. Doremus and myself. The circuit, taken two and a half feet from the inside, measured $735\frac{84}{100}$ feet. This measurement was made with a metallic tape, adjusted for temperature and tested in our presence. In making the measurement, Prof. Doremus was at one end of the tape and I was at the other, and every reading was carefully verified. Seven full circuits and $129\frac{12}{100}$ additional feet made a full mile. In computing the walk, the distance was noted by circuits. Three judges were in attendance day and night; one calling the time of each circuit, and two checking off the circuits in a book provided for that purpose. In addition, either Prof. Doremus, Prof. Mott, or myself, was constantly present. Mr. Weston had retiring-rooms in the front of the building, where his food was prepared, where he slept, and where our observations were taken. The distance from the judge's stand to the door of these rooms was $145\frac{75}{100}$ feet.

During the walk, Mr. Weston took but few regular meals, a great part of his nourishment being taken while actually walking. In this way he took his beef-essence, soft-boiled eggs, gruel, tea, coffee, and all other drinks. I shall not, therefore, give the time of the meals taken during this period, but simply state the entire quantity consumed in each twenty-four hours.

With regard to the distance walked, we are all satisfied that there is no room for doubt. But, although the task proposed was not accomplished, the effort, as a feat of pedestrianism, was so prodigious, that I have thought it best to give the history of these five days pretty fully in detail.

November 21st, First Day.

The following is a summary of the twenty-four hours of November 21st:

12 00 to 12 15 A. M.	15 minutes' rest before starting.
12 15 to 4 9 "	3 h. 54 m. walking 20 miles, with 4 stops for urination, averaging 24 sec. each.
4 9 to 7 58 "	3 h. and 49 m. rest (sleep).
7 58 to 9 6 "	1 h. and 8 m. walking 5¾ miles.
9 6 to 9 19 "	13 m. for breakfast.
9 19 A. M. to 1 P. M.	3 h. and 41 m. walking 17 miles, with 5 m. 12 sec. for defecation, and 2 stops for urination, averaging 30 sec. each.
1 00 to 1 46 "	46 m. for dinner.
1 46 to 3 25 "	1 h. and 39 m. walking 8 miles, with 2 stops for urination, averaging 27½ sec. each.
3 25 to 3 32 "	7 minutes' rest, sitting on the track.
3 32 to 5 34 "	2 h. and 2 m. walking 9¼ miles, with 2 stops for urination, averaging 26½ sec. each.
5 34 to 6 27 "	53 minutes' rest (supper).
6 27 to 8 38 "	2 h. and 11 m. walking 12 miles, with 3 stops for urination, averaging 26 sec. each.
8 38 to 8 48 "	10 minutes' rest, sitting on the track.
8 48 to 10 32½ "	1 h. 44½ m. walking 8 miles, with 2 stops for urination, averaging 32½ sec. each.
10 32½ to 12 00 "	1 h. 27½ minutes' rest, continued into November 22d, 4 h. 58 m.

During the 24 hours of November 21st, Mr. Weston walked 80 miles in 16 h. and 20 m., including 5 m. 12 sec. for defecation, and 6 m. 45 sec. for urination. Deducting the time for defecation and urination, his walking-time was 16 h. 8 m. and 3 sec., and he averaged a fraction less than 5 miles per hour. He had 17 minutes' rest, sitting by the track, and 7 h. and 23 m. for breakfast, dinner, supper, and sleep. He urinated 15 times on the track. He vomited a little liquid twice during the night, at 10.50 and 11.15. He slept during the twenty-four hours, about 1 hour.

Walking 80 miles....	16 h.	8 m.	3 sec.
Defecation..........		5 "	12 "
Urination...........		6 "	45 "
Rest on the track.....		17 "	
Rest off the track....	7 h.	23 "	
	23 h.	59 m	60 sec.=24 hours.

During the whole of the first day, Mr. Weston seemed to feel very well, and made his walk with great ease. He was a little nauseated at times, but he stated that he had always more or less disturbance of that kind when he first commenced to walk. He had perfect confidence that he would accomplish the entire walk, as originally proposed.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Mutton-chops.........	2.00	30.62
Eggs................	6.90	57.35
Milk	5.66	16.34
Bread...............	1.25	5.91
Butter	2.63	7.36
Sugar...............	1.63	00.00
Coffee	67.67	32.57
Tea	16.03	1.40
Water	6.75	00.00
Lemonade	71.16	00.00
Molasses-and-Water...	4.40	00.00
Salt	0.08	00.00
Pepper..............	0.05	00.00
Bicarbonate of potash.	0.04	00.00
	186.25	151.55
	(5,282.38 grammes.)	(9.820 grammes.)

Total ingesta......... (11 lbs., 10 $\frac{25}{100}$ oz.)

Liquids.............. (10 lbs., 11 $\frac{67}{100}$ oz.)

Analysis of Excretions of Twenty-four Hours.

URINE.

Quantity............................	42.09 fl ℥	(1,245.0 c. c.)	
Specific gravity	1028.6		
Urea..................................	710.00 grains,	46.065	grammes.
Nitrogen in urea......................	331.33 "	21.497	"
Uric acid.............................	0.32 "	0.021	"
Phosphoric acid.......................	84.95 "	5.504	"
Sulphuric acid	73.39 "	4.755	"
Chloride of sodium...................	96.00 "	6.220	"

This specimen of urine presented rather a faint, cloudy sediment, which contained a large number of octahedra of the oxalate of lime.

FÆCES.

Quantity	4.80 oz. av.	136.0 grammes.
Nitrogen	25.77 grains,	1.670 "

Nitrogen in urea and fæces combined.... 357.10 grains, 22.167 "

Nitrogen of urea and fæces per 100 parts of nitrogen of food. 235.63 parts.

Uric acid per 100 parts of urea.......................... 0.045 "

10.40 P. M.	Weight (naked)..........	116.5 lbs. (52 k. 838 grammes.)
	Temperature under the tongue......	95.3° (35.3° C.)
	Pulse............................	98.
	Respirations......................	20.

November 22d, Second Day.

The following is a summary of the twenty-four hours of November 22d:

12 00 to 4 58 A. M.	4 h. and 58 m. rest, continued from November 21st, before starting, making, during the night of the 21st and 22d, 6 h. and 25½ minutes.
4 58 to 6 58 "	2 h. walking 8 5/7 miles, with 1 stop of 6 m. for defecation.
6 58 to 7 8 "	10 m. rest, sitting on the track.
7 8 to 7 33 "	25 m. walking 1 5/7 miles.
7 33 to 9 5 "	1 h. and 32 m. rest (breakfast).
9 5 to 11 12 "	2 h. and 7 m. walking 9 4/7 miles, with 2 stops for urination, averaging 32 sec. each.
11 12 to 11 27 "	15 m. rest, sitting on the track.
11 27 to 1 41 P. M.	2 h. and 14 m. walking 10 miles, with 2 m. rest and 2 stops for urination, averaging 29 sec. each.
1 41 to 1 55 "	14 m. rest, sitting on the track.
1 55 to 4 5 "	2 h. and 10 m. walking 10 miles, with 1 stop for urination, of 25 sec.
4 5 to 10 24 "	6 h. 19 m. Stopped for sleep, but dozed only. Ate supper before starting again.
10 24 to 12, less 49 sec.	Walking 8 miles in 1 h. 36 m. less 49 sec. on his walk of 112 miles in 24 h., and continued walking into November 23d.

During the 24 hours of November 22d, Mr. Weston walked 48 miles in 10 h. and 32 m., including 6 m. for defecation, and 2 m. 27 sec. for urinaation. Deducting the time of defecation and urination, his walking-time was 10 h. 23 m. and 33 sec., and he averaged about 4.62 miles per hour. He had 39 minutes' rest, sitting on the track, and 12 h. and 49 m. for breakfast, dinner, supper, and sleep. He urinated 5 times on the track. When he stopped, at 4.5 P. M., he was undressed, and wrapped in a long red-flannel gown and a blanket, carried to a vehicle, and driven about five blocks to a private house to sleep. He states that he did not sleep, but dozed, and got no rest. About 9.30 P. M., he was brought back to the rink in the same way that he was taken out, ate supper, and began at 10.24 P. M. his first attempt to walk one hundred and twelve miles in twenty-four consecutive hours. He seemed cheerful and confident during the entire day. He slept, during the twenty-four hours, 4 hours and 28 minutes.

Walking 48 miles..	10 h.	23 m.	33 sec.
Defecation		6 "	
Urination..........		2 "	27 "
Rest on the track..		39 "	
Rest off the track..	12 "	49 "	
	22 h.	119 m.	60 sec.=24 hours.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Roast beef	4.00	61.25
Chicken	2.25	34.45
Eggs	8.28	68.82
Milk	5.66	16.34
Bread	10.50	49.61
Potatoes	2.00	2.89
Butter	0.50	1.40
Sugar	1.75	00.00
Coffee	57.82	27.83
Tea	38.08	3.33
Lemonade	34.84	00.00
Salt	0.08	00.00
Pepper	0.05	00.00
	165.81	265.92
	(4,700.13 grammes.)	(17,229 grammes.)

Total ingesta........ (10 lbs., 5 $\frac{81}{100}$ oz.)
Liquids............. (8 lbs., 8 $\frac{40}{100}$ oz.)

Analysis of Excretions of Twenty-four Hours.

URINE.

Quantity	33.50 fl ℥. (991.0 c.c.)			
Specific gravity	1030.0.			
Urea	702.86 grains,		45.540 grammes.	
Nitrogen in urea	328.00	"	21.252	"
Uric acid	0.14	"	0.009	"
Phosphoric acid	72.14	"	4.674	"
Sulphuric acid	56.90	"	3.687	"
Chloride of sodium	91.68	"	5.940	"

This specimen of urine presented rather a faint, cloudy sediment, which contained a large number of octahedra of the oxalate of lime.

FÆCES.

Quantity.................................. 7.94 oz. av., 225.0 grammes.
Nitrogen.................................. 42.64 grains, 2.763 "

Nitrogen in urea and fæces combined......370.64 " 24.015 "

Nitrogen of urea and fæces per 100 parts of nitrogen of food..139.39 parts.
Uric acid per 100 parts of urea............................ 0.020 "

10 P. M.
- Weight (naked)...........116.25 lbs. (52k. 724 grammes.)
- Temperature under the tongue............94.8° (34.9°C.)
- Pulse....................................93.
- Respirations.............................23.

November 23d, Third Day.

The following is a summary of the twenty-four hours of November 23d:

12 00 to 6 6 A. M.	6 h. and 6 m. walking 27¼ miles, with one stop of 4 m. 30 sec. for rest, and 4 stops for urination, averaging 30½ sec. each.
6 6 to 6 14 "	8 minutes' rest, sitting on the track.
6 14 to 1 31 P. M.	7 h. and 17 m. walking 33 miles, with 4 stops for urination, averaging 31¼ sec. each.
1 31 to 1 37 "	6 minutes' rest, sitting on the track.
1 37 to 2 24 "	47 m. walking 3¾ miles, with one stop of 34 sec. for urination.
2 24 to 2 31 "	7 minutes' rest, sitting on the track.
2 31 to 3 5 "	34 m. walking 2¾ miles.
3 5 to 3 32 "	27 minutes' rest, sitting on the track.
3 32 to 4 46 "	1 h. 14 m. walking 5¼ miles, including 2 stops for urination, averaging 27½ sec. each.
4 46 to 5 16 "	30 minutes' rest, sitting on the track.
5 16 to 5 46 "	30 m. walking 2 miles, with one stop of 58 sec. for urination.
5 46 to 6 49 "	1 h. and 3 m. rest in his room (supper).
6 49 to 9 11 "	2 h. and 22 m. walking 11 miles, with one stop of 30 sec. for urination.
9 11 to 9 21 "	10 minutes' rest, sitting on the track.
9 21 to 10 52 "	1 h. and 31 m. walking 7 miles, with one stop of 43 sec. for urination.
10 52 to 12 00 M.	1 h. and 8 m. rest, continued into November 24th.

During the 24 hours of November 23d, Mr. Weston walked 92 miles in 20 h. and 21 m., including 4 m. 30 sec. rest, and 7 m. 47 sec. for urination. His walking-time was 20 h. 8 m. and 43 sec., and he averaged a fraction more than 4½ miles per hour. He had 1 h. 32 m. and 30 sec. rest, sitting on the track, and 2 h. and 11 m. rest in his room. Before 12, midnight, November 22d, he had walked 8 miles in 1 h. 35 m. and 11 sec., making 100 miles in 24 h. and 28 m. His last rest of 1 h. and 8 m. was continued into November 24th 1 h. and 33 m. He urinated on the track 14 times.

During the early part of the day, Mr. Weston seemed cheerful and confident, but after walking about sixty miles, he complained very much of drowsiness, and found it absolutely impossible to make the time necessary to accomplish his hundred and twelve miles in twenty-four consecutive hours. He stated that he was not fatigued, but suffered only from want of sleep. He was not much depressed at his first failure, as he intended to make a second trial of the hundred-and-twelve-mile walk.

He commenced, 10.24 P. M., November 22d, his first attempt to make 112 miles in 24 consecutive hours. He failed on account of want of sleep, not having slept well the six hours before the attempt. He had no passage from his bowels during this 24 hours. He slept, during the 24 hours, 30 minutes.

Walking 92 miles..........	20 h.	8 m.	43 sec.
Urination		7 m.	47 sec.
Rest on the track..........	1 h.	32 m.	30 sec.
Rest off the track..........	2 h.	11 m.	
	23 h.	58 m.	120 sec.=24 hours

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Beef-essence............	22.26	84.73
Eggs....................	8.28	68.82
Milk....................	6.18	17.84
Bread...................	1.50	7.09
Oatmeal-gruel...........	6.78	2.55
Butter..................	0.50	1.40
Sugar...................	2.00	00.00
Coffee..................	95.95	46.18
Lemonade................	27.56	00.00
Salt....................	0.08	00.00
Pepper..................	0.05	00.00
	171.14	228.61
	(4,851.22 grammes.)	(14.812 grammes.)

Total ingesta..........(10 lbs., $11\frac{14}{100}$ oz.)
Liquids...............(9 lbs., $14\frac{73}{100}$ oz.)

Analysis of Excretions of Twenty-four Hours.

URINE.

Quantity...........................	40.56 fl ℥.	(1,200.0 c.c.)		
Specific gravity......................	1032.5.			
Urea..............................	851.95	grains,	55.200	grammes.
Nitrogen in urea.....................	397.58	"	25.760	"
Uric acid..........................	4.74	"	0.307	"
Phosphoric acid......................	102.25	"	6.625	"
Sulphuric acid......................	63.71	"	4.128	"
Chloride of sodium..................	44.45	"	2.880	"

This specimen presented a whitish, flocculent, and rather copious sediment, which contained a large number of crystals of the oxalate of lime.

NO FÆCES PASSED.

Nitrogen of urea (no fæces) per 100 parts of nitrogen of food 173.91 parts.
Uric acid per 100 parts of urea........................ 0.566 "

11.15 P. M.	Weight inaccurately taken..............	
	Temperature under the tongue...........	96.6° (35.9° C
	Pulse (76 at 5 P. M.)....................	109.
	Respirations...........................	22.

November 24th, Fourth Day.

The following is a summary of the twenty-four hours of November 24th:

12 00 to 1 33 A. M.	1 h. 33 m. rest in room, continued from November 23d, making in all, 2 h. 41 m. rest for the night of November 23d and 24th.
1 33 to 4 12 "	2 h. 39 m. walking 10 miles, with 3 m. stop for defecation, and 30 sec. for urination.
4 12 to 9 59 "	5 h. and 47 m. rest in room.
9 59 to 2 58 P. M.	4 h. 59 m. walking 23$\frac{4}{7}$ miles, with 3 stops for urination, averaging 30$\frac{1}{3}$ sec. each.
2 58 to 3 3 "	5 minutes' rest, sitting on the track.
3 3 to 6 10 "	3 h. and 7 m. walking 14$\frac{3}{7}$ miles, with 2 stops for urination, averaging 42$\frac{1}{2}$ sec. each.
6 10 to 6 13 "	3 minutes' rest, sitting on the track.
6 13 to 6 29 "	16 m. walking 1$\frac{5}{7}$ miles, with 30 sec. for urination.
6 29 to 6 39 "	10 minutes' rest, sitting on the track.
6 39 to 6 51 "	12 m. walking 1 mile.
6 51 to 7 3 "	12 minutes' rest in his room.
7 3 to 7 10 "	7 m. walking $\frac{4}{7}$ of a mile.
7 10 to 8 6 "	56 minutes' rest in his room.
8 6 to 8 16 "	10 m. walking $\frac{5}{7}$ of a mile, with 40 sec. for urination.
8 16 to 8 21 "	5 minutes' rest, sitting on the track.
8 21 to 8 54 "	33 m. walking 2$\frac{1}{7}$ miles.
8 54 to 9 2 "	8 minutes' rest, sitting on the track.
9 2 to 9 21 "	19 m. walking 1$\frac{4}{7}$ miles.
9 21 to 9 31 "	10 minutes' rest, sitting on the track.
9 31 to 9 48 "	17 m. walking 1 mile, with 50 sec. for urination.
9 48 to 10 21 "	33 minutes' rest in room.
10 21 to 10 30 "	9 m. walking $\frac{3}{7}$ of a mile.
10 30 to 12 00 M.	1 h. and 30 m. rest in room, continued into November 25th.

During the 24 hours of November 24th, Mr. Weston walked 57 miles in 12 h. and 48 m., including 3 m. for defecation, and 5 m. and 26 sec. for urination. His walking-time was 12 h. 39 m. and 34 sec., averaging almost exactly 4$\frac{1}{2}$ miles per hour. He had 41 m. rest, sitting on the track, and 10 h. and 31 m. rest in his room. He urinated on the track 10 times. His last rest, 1 h. and 30 m., was continued into November 25th, for 9 h. 56 m., making, during the night of November 24th and 25th, 11 h. 26 m. rest.

He commenced, at 10.13 A. M., his second attempt to walk 112 miles in 24 consecutive hours. At 6.51 P. M. he became very dizzy. This increased so that he staggered, and could hardly see the track. After 6 rests and 6 attempts to continue his walk, he was forced to abandon the attempt at

10.30 P. M. He was excessively depressed at his failure, as it was then impossible for him to accomplish the four hundred miles in five days. He took nothing but a little food, lay down, and went to sleep about midnight. He slept during this twenty-four hours, 1 hour; but his sleep was continued into the next day.

Walking 57 miles..........	12 h.	39 m.	34 sec.
Defecation................		3 m.	
Urination.................		5 m.	26 sec.
Rest on the track..........		41 m.	
Rest off the track..........	10 h.	31 m.	
	22 h.	119 m.	60 sec.=24 hours.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Roast beef..............	1.62	24.81
Beef-essence............	10.33	39.32
Milk....................	8.75	25.27
Bread...................	6.62	31.28
Oatmeal-gruel...........	7.92	2.92
Sugar...................	3.62	00.00
Coffee..................	38.38	18.47
Tea.....................	30.06	2.63
Lemonade................	41.60	00.00
Salt....................	0.08	00.00
Pepper..................	0.05	00.00
Bicarbonate of potash....	0.04	00.00
	149.07 (4,225.61 grammes.)	144.70 (9.376 grammes.)

Total ingesta............(9 lbs., $5\frac{7}{100}$ oz.)

Liquids.................(8 lbs., $9\frac{4}{100}$ oz.)

Analyses of Excretions of Twenty-four Hours.

URINE.

Quantity............................	32.52 fl ℥	(965.0 c.c.)
Specific gravity....................	1029.6	
Urea................................	688.98 grains,	44.641 grammes.
Nitrogen in urea....................	321.52 "	20.832 "
Uric acid...........................	9.21 "	0.597 "
Phosphoric acid.....................	66.30 "	4.296 "
Sulphuric acid......................	32.66 "	2.116 "
Chloride of sodium..................	28.78 "	1.865 "

This urine presented a faint deposit, like mucus, which contained a moderate number of octahedra of the oxalate of lime, with a few granules of amorphous urates.

FÆCES.

Quantity...........................	5.03 oz. av.	142.5	grammes.
Nitrogen...........................	21.01 grains,	1.750	"
Nitrogen in urea and fæces combined...348.53	"	22.582	"

Nitrogen of urea and fæces per 100 parts of nitrogen of food..240.86 parts.
Uric acid per 100 parts of urea........................... 1.336 "

10.40 P. M.	Weight (naked)............114 lbs. (51 k. 704 grammes.)
	Temperature under the tongue........ 96.6° (35.9° C.)
	Pulse............................ 68.
	Respirations........................ 18.

November 25th, Fifth Day.

The following is a summary of the twenty-four hours of November 25th:

12 00 to 9 56 A. M.	9 h. and 56 m. rest before starting, with 1 h. 30 m. of November 24th, make 11 h. 26 m. rest for the night of November 24th and 25th.
9 56 to 10 11 "	15 m. walking 1 mile.
10 11 to 10 16 "	5 minutes' rest in room.
10 16 to 10 58 "	42 m. walking 3 miles, with 1 m. for urination.
10 58 to 11 21 "	23 minutes' rest, sitting on the track.
11 21 to 11 52 "	31 m. walking 2$\frac{2}{7}$ miles.
11 52 to 12 42 P. M.	50 minutes' rest in room.
12 42 to 1 1 "	19 m. walking 1$\frac{5}{7}$ mile, with 30 sec. for urination.
1 1 to 2 39 "	1 hour 38 minutes' rest in room.
2 39 to 4 19 "	1 h. 40 m. walking 7 miles, with 25 sec. for urination.
4 19 to 4 34 "	15 minutes' rest in room.
4 34 to 6 19 "	1 h. and 45 m. walking 8 miles, with 2 stops for urination, averaging 29½ sec. each.
6 19 to 7 43 "	1 hour and 24 minutes' rest in room.
7 43 to 9 32 "	1 h. and 49 m. walking 9 miles, with 40 sec. for urination.
9 32 to 9 50 "	18 minutes' rest, sitting on the track.
9 50 to 11 31 "	1 h. and 41 m. walking 7 miles, with 2 stops for urination, averaging 25 sec. each.
11 31 to 11 41 "	10 minutes' rest, sitting on the track.
11 41 to 12 00 M.	19 m. walking 1½ miles.

During the twenty-four hours of November 25th, Mr. Weston walked 40½ miles in 9 h. and 1 m., including 4 m. and 24 sec. for urination. His walking-time was 8 h. 56 m. and 36 sec., averaging a fraction more than 4½ miles per hour. He had 51 minutes' rest sitting on the track, and 14 h. and 8 m. rest in his room. He urinated on the track 7 times. After 12 M., he was in remarkably fine condition. He made several rounds in less than 1 minute, one round in 54 sec., on his thirtieth mile, which was done in 8 m. 32 sec. He walked about 1 mile from 12 to 12.15 A. M., November 26th. At the conclusion of his walk, he was in the best of health and spirits. He slept, during the twenty-four hours, 9 hours and 26 minutes.

Walking 40½ miles...	8 h.	56 m.	36 sec.
Urination...........		4 "	24 "
Rest on the track....		51 "	
Rest in his room.....	14 h.	8 "	
	22 h.	119 m.	60 sec.=24 hours.

TOTAL MILES WALKED.

Nov. 21st........................	80 miles.
" 22d........................	48 "
" 23d........................	92 "
" 24th........................	57 "
" 25th........................	40½ "
	317½ miles.

In going thirty-two times to his room, Mr. Weston walked, in addition to the above, 0.883 of a mile. From midnight, November 25th, to 12.15 A. M., November 26th, he walked 1¼ miles, to complete his five days. This, with the few feet to the urinal, makes about 320 miles in five consecutive days.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Roast beef...........	3.00	45.94
Chicken..............	11.00	168.44
Beef-essence..........	9.54	36.31
Eggs.................	4.14	34.41
Milk.................	9.78	28.24
Bread................	9.00	42.52
Potatoes..............	4.00	5.77
Oatmeal-gruel.........	3.39	1.28
Butter...............	1.25	3.50
Sugar................	2.37	00.00
Tomatoes.............	3.12	00.00
Coffee...............	27.27	13.12
Tea..................	40.08	3.51
Lemonade.............	52.00	00.00
Water................	5.00	00.00
Salt.................	0.08	00.00
Pepper..............	0.05	00.00
	185.07	383.04
	(5,246.09 grammes.)	(24.818 grammes.)

Total ingesta.......... (11 lbs., $9\frac{7}{100}$ oz.)

Liquids.............. (9 lbs., $7\frac{6}{100}$ oz.)

Analyses of Excretions of Twenty-four Hours.

URINE.

Quantity	43.60 fl ℥	(1,290.0 c. c.)
Specific gravity	1022.6	
Urea	657.02 grains,	42.570 grammes.
Nitrogen in urea	306.61 "	19.866 "
Uric acid	0.57 "	0.037 "
Phosphoric acid	57.49 "	3.725 "
Sulphuric acid	40.84 "	2.646 "
Chloride of sodium	64.50 "	4.179 "

This urine presented a whitish, grumous sediment, rather copious, which contained a few octahedra of the oxalate of lime, with a few granules of amorphous phosphates.

FÆCES.

Quantity	4.87 oz. av.	138.0 grammes.
Nitrogen	26.16 grains,	1.695 "
Nitrogen in urea and fæces combined	332.77 "	21.561 "

Nitrogen of urea and fæces per 100 parts of nitrogen of food . . 84.27 parts.
Uric acid per 100 parts of urea . . . 0.087 "

1.30 A. M., Nov. 26th.	Weight (naked)	115.75 lbs. (52 k. 497 grammes.)
	Temperature under the tongue	97.9° (36.6° C.)
	Pulse	80.
	Respirations	20.

Third Period.—Five Days after the Walk.

Notwithstanding the immense muscular and nervous strain to which Mr. Weston had subjected himself for the past five days, culminating on the fourth day in complete prostration of the nervous system, he sat up, talked and joked with his friends until 1.40 A. M., November 26th, then went to bed, and slept well until 10 A. M. He then got up, feeling splendidly; wakening his attendants, who were almost exhausted by the five days' labor and watching, and called for his breakfast, which he ate at 11.45, with excellent appetite. For the succeeding five days, he felt as well as ever. During these five days, he did absolutely nothing but eat, sleep, and amuse himself, attending to no business. He took no exercise, walking only about two miles a day, though he said he felt as if he could walk one hundred miles any day without difficulty. The history of this period closed our investigations.

November 26th, First Day.

Mr. Weston slept well. He took breakfast at 11.45 A. M., and dinner at 6.45 P. M. He smoked during the day, six cigars. He walked two miles. He slept, during the twenty-four hours, 8 hours and 20 minutes.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Turkey	7.50	114.84
Chicken	5.12	78.40
Fish	3.50	53.59
Eggs	4.14	34.41
Milk	2.06	5.95
Custard	3.25	18.20
Ice-cream	3,50	19.60
Bread	7.75	36.62
Potatoes	5.00	7.22
Butter	1.88	5.26
Sugar	0.88	00.00
Cauliflower	3.00	00.00
Cranberries	5.00	00.00
Celery	1.00	00.00
Lettuce	1.25	00.00
Grapes	1.00	00.00
Apples	5.00	00.00
Coffee	24.24	11.56
Lemonade	14.68	00.00
Water	30.00	00.00
Salt	0.15	00.00
Pepper	0.05	00.00
	129.95	385.65
	(3,683.63 grammes.)	(24.987 grammes.)

Total ingesta......... (8 lbs., $1\frac{95}{100}$ oz.)

Liquids............. (2 lbs., $14\frac{74}{100}$ oz.)

Analysis of Excretions of Twenty-four Hours.

URINE.

Quantity	31.59 fl ℥	(937.5 c. c.)		
Specific gravity	1025.8			
Urea	593.23	grains,	38.437	grammes.
Nitrogen in urea	276.84	"	17.937	"
Uric acid	0.48	"	0.031	"
Phosphoric acid	29.06	"	1.883	"
Sulphuric acid	49.53	"	3.209	"
Chloride of sodium	66.41	"	4.303	"

This urine presented a rather heavy, whitish sediment, in considerable quantity, which contained numerous granules of the amorphous urates, with a very few octahedra of the oxalate of lime.

FÆCES.

Quantity	3.51 oz. av.	99.5	grammes.
Nitrogen	18.86 grains,	1.222	"
Nitrogen in urea and fæces combined	295.70 "	19.159	"

Nitrogen of urea and fæces per 100 parts of nitrogen of food..76.68 parts.
Uric acid per 100 parts of urea.......................... 0.081 "

12.10 A. M., Nov. 27th.
- Weight (naked)...........118 lbs. (53 k. 518 grammes.)
- Temperature under the tongue........... 98.6° (37° C.)
- Pulse.................................. 76.
- Respirations........................... 22.

November 27th, Second Day.

Mr. Weston slept well. He took breakfast at 10 A. M.; dinner at 2 P. M.; and supper at 6.45 P. M. He smoked during the day, seven cigars. He walked about two miles. He slept, during the twenty-four hours, 8 hours and 15 minutes.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Beefsteak	5.00	76.56
Roast beef	2.50	38.28
Turkey	9.00	137.81
Head-cheese	1.50	14.70
Eggs	4.14	34.41
Milk	5.14	14.87
Bread	16.15	76.31
Cheese	1.13	20.28
Potatoes	10.25	14.82
Oysters	3.90	36.34
Ice-cream	2.88	16.13
Butter	2.75	7.70
Sugar	1.56	00.00
Tomatoes	5.25	00.00
Cranberries	4.50	00.00
Preserves	4.75	00.00
Catsup	0.42	00.00
Coffee	19.19	9.23
Tea	19.04	1.66
Molasses-and-Water	21.45	00.00
Water	40.00	00.00
Salt	0.05	00.00
Pepper	0.06	00.00
	180.61	499.10
	(5,119.66 grammes.)	(32.338 grammes.)

Total ingesta......... (11 lbs., $4\frac{61}{100}$ oz.)
Liquids.............. (6 lbs., $8\frac{82}{100}$ oz.)

Analysis of Excretions of Twenty-four Hours.

URINE.

Quantity	46.14 fl ℥	(1,365.0 c. c.)		
Specific gravity	1024.4			
Urea	716.29	grains,	46.410	grammes.
Nitrogen in urea	334.27	"	21.658	"
Uric acid	0.52	"	0.034	"
Phosphoric acid	46.93	"	3.041	"
Sulphuric acid	46.07	"	2.985	"
Chloride of sodium	170.64	"	11.056	"

This urine presented a slight sediment of a whitish appearance, which contained a few octahedra of the oxalate of lime, and a few groups of small crystals of uric acid.

FÆCES.

Quantity	4.57 oz. av.	129.5	grammes.
Nitrogen	24.54 grains,	1.590	"
Nitrogen in urea and fæces combined	358.81 "	23.248	"

Nitrogen of urea and fæces per 100 parts of nitrogen of food	71.81	parts.
Uric acid per 100 parts of urea	0.072	"

11. P. M.	Weight (naked)	120.25 lbs. (54 k. 539 grammes.)
	Temperature under the tongue	98.4° (36.9° C.)
	Pulse	73.
	Respirations	22.

November 28th, Third Day.

Mr. Weston slept well. He took breakfast at 8.50 A. M.; dinner at 4.15 P. M.; and supper at 7.45 P. M. He smoked during the day, five cigars. He walked about two miles. He slept, during the twenty-four hours, 8 hours and 50 minutes.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Beefsteak	9.37	143.48
Oysters	5.62	53.37
Eggs	4.14	34.41
Milk	9.27	26.76
Cream-cakes	3.37	18.97
Bread	11.62	54.80
Cheese	1.25	22.53
Potatoes	11.00	15.88
Butter	2.75	7.70
Sugar	2.78	00.00
Tomatoes	3.75	00.00

	Oz. Av.	Nitrogen, in grains.
Sweet pickles........	2.18	00.00
Apples..............	3.12	00.00
Grapes..............	2.75	00.00
Coffee..............	32.32	15.53
Tea.................	16.03	1.40
Salt................	0.06	00.00
Pepper..............	0.06	00.00
Vinegar.............	0.25	00.00
	121.69	394.83
	(3,449.49 grammes.)	(25.582 grammes.)

Total ingesta. .... (7 lbs., $9\frac{69}{100}$ oz.)
Liquids .... (3 lbs., $9\frac{87}{100}$ oz.)

Analysis of Excretions of Twenty-four Hours.

URINE.

Quantity..............................	84.18 fl ℥	(2,490.0 c. c.)		
Specific gravity......................	1019.7			
Urea..................................	768.61	grains,	49.800	grammes.
Nitrogen in urea......................	358.68	"	23.240	"
Uric acid.............................	0.31	"	0.020	"
Phosphoric acid.......................	105.68	"	6.847	"
Sulphuric acid........................	53.57	"	3.471	"
Chloride of sodium....................	622.58	"	40.338	"

This urine presented a slight sediment of a whitish appearance, which contained a few octahedra of the oxalate of lime, and a few groups of small crystals of uric acid.

FÆCES.

Quantity..............................	9.53 oz. av.	270.0	grammes.
Nitrogen..............................	51.19 grains,	3.316	"
Nitrogen in urea and fæces combined...	409.87 "	26.556	"

Nitrogen in urea and fæces per 100 parts of nitrogen of food..103.81 parts.
Uric acid per 100 parts of urea.......................... 0.040 "

10.30 P. M.
- Weight (naked).........120.25 lbs. (54 k. 539 grammes.)
- Temperature under the tongue......... 99.3° (37.4° C.)
- Pulse.............................. 70.
- Respirations....................... 22.

November 29th, Fourth Day.

Mr. Weston slept well. He took breakfast at 9.35 A. M.; dinner at 2 P. M.; supper at 6.30 A. M.; and a second supper (which weighed 3 lbs., 6.75 oz. av.) at 11.15 P. M. He smoked five cigars during the day. He walked about two miles. He slept, during the twenty-four hours, 7 hours and 35 minutes.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Beefsteak	4.25	65.08
Roast beef	2.75	42.11
Chicken	15.00	229.69
Eggs	4.14	34.41
Milk	6.25	18.05
Bread	18.63	88.03
Potatoes	13.50	20.59
Cheese	1.00	18.03
Rice-pudding	14.75	77.15
Butter	5.12	14.33
Sugar	2.12	00.00
Tomatoes	7.38	00.00
Tomato-soup	8.00	00.00
Celery	1.00	00.00
Figs	2.37	9.54
Apples	7.00	00.00
Coffee	48.48	23.30
Tea	16.03	1.40
Water	10.00	00.00
Salt	0.16	00.00
Pepper	0.08	00.00
	188.01	641.71
	(5.329.43 grammes.)	(41.578 grammes.)

Total ingesta........ (11 lbs., $12\frac{1}{100}$ oz.)
Liquids............. (5 lbs., $8\frac{76}{100}$ oz.)

Analysis of Excretions of Twenty-four Hours.

URINE.

Quantity	60.38 fl ℥	(1,786.0 c. c.)		
Specific gravity	1022.5			
Urea	744.32 grains,	48.226 grammes.		
Nitrogen in urea	347.35	"	22.505	"
Uric acid	2.51	"	0.163	"
Phosphoric acid	50.76	"	3.289	"
Sulphuric acid	48.73	"	3.157	"
Chloride of sodium	297.70	"	19.288	"

This urine presented hardly any sediment. The microscopical examination was entirely negative.

FÆCES.

Quantity	6.61 oz. av.	187.5	grammes.
Nitrogen	35.54 grains,	2.303	"
Nitrogen in urea and fæces combined	382.89 "	24.808	"

Nitrogen of urea and fæces per 100 parts of nitrogen of food.. 59.67 parts.
Uric acid per 100 parts of urea.......................... 0.337 "

12.20 A. M., Nov. 30th.	Weight[1] (naked).........123.5 lbs. (56 k. 13 grammes.)	
	Temperature under the tongue..........	98.8° (37.1° C.)
	Pulse..................................	78.
	Respirations...........................	24.

November 30*th*, *Fifth Day*.

Mr. Weston slept well. He took breakfast at 9.15 A. M.; dinner at 1.45 P. M.; and supper at 6.15 P. M. He smoked during the day, six cigars. He walked about three miles. He had a headache all the evening. He slept, during the twenty-four hours, 7 hours and 45 minutes. The records were closed at midnight.

Weights and Analyses of Food and Drink for the Twenty-four Hours.

	Oz. Av.	Nitrogen, in grains.
Beefsteak............	1.88	28.79
Roast beef...........	3.37	51.60
Fish.................	3.00	45.94
Milk.................	5.66	16.34
Bread................	21.00	99.22
Potatoes.............	5.94	8.58
Butter...............	4.12	11.54
Sugar................	1.88	00.00
Tomatoes.............	3.12	00.00
Tomato-soup..........	8.00	00.00
Figs.................	2.06	8.29
Preserved citron......	2.25	00.00
Coffee...............	24.24	11.65
Tea..................	16.03	1.40
Salt.................	0.06	00.00
Pepper...............	0.06	00.00
	102.67	283.35
	(2,910.34 grammes.)	(18.359 grammes.)

Total ingesta......... (6 lbs., $6\frac{67}{100}$ oz.)
Liquids.............. (2 lbs., $15\frac{93}{100}$ oz.)

[1] This great increase in weight is accounted for by 3 lbs. 6.75 oz. of food taken at 11.15 P. M.

Analysis of Excretions of Twenty-four Hours.

URINE.

Quantity	68.39 fl ℥	(2,023.0 c. c.)		
Specific gravity	1022.6			
Urea	811.48	grains,	52.598	grammes.
Nitrogen in urea	378.69	"	24.546	"
Uric acid	3.30	"	0.214	"
Phosphoric acid	52.00	"	3.364	"
Sulphuric acid	47.20	"	3.058	"
Chloride of sodium	404.65	"	26.218	"

This urine presented a cloudy sediment in moderate quantity, which contained a moderate number of octahedra of the oxalate of lime.

FÆCES.

Quantity	7.41 oz. av.	210.0	grammes.
Nitrogen	39.80 grains,	2.579	"
Nitrogen in urea and fæces combined	418.49 "	27.125	"

Nitrogen of urea and fæces per 100 parts of nitrogen of food . . 147.69 parts.
Uric acid per 100 parts of urea . . . . 0.406 "

12 M.	Weight (naked)	120.75 lbs. (54 k. 765 grammes.)
	Temperature under the tongue	97.5° (36.4° C.)
	Pulse	76.
	Respirations	24.

CONSOLIDATED TABLES.

I propose to present, in a series of consolidated tables, the complete history of the fifteen days, divided, as before, into three periods of five days each, in the form in which they will be made use of in Part II. in making the final deductions. I present them in this form complete, so that all or any part of them may serve as material for others. The cutaneous and pulmonary exhalations are estimated by subtracting the weight of urine and fæces from the weight of ingesta; to this result adding any loss of weight, or subtracting from it any gain in the weight of the body during the twenty-four hours.

The weights are given in pounds and ounces avoirdupois, and in grains troy. The equivalents in French weights are given in parentheses:

TABLE A[1].

Weight, Temperature, Pulse, etc.

First Period—Five Days before the Walk.

	1st Day, Nov. 16th.	2d Day, Nov. 17th.	3d Day, Nov. 18th.	4th Day, Nov. 19th.	5th Day, Nov. 20th.
Weight of the body (naked).	120.5 lbs. (54 k.655 gr.)	121.25 lbs. (55 kilogr.)	120 lbs. (54 k.432 gr.)	118.5 lbs. (53 k.745 gr.)	119.2 lbs. (54 k. 62 gr.)
Temperature under tongue..	99.7° Fahr. (37.6° C.)	98.4° Fahr. (36.9° C.)	98° Fahr. (36.7° C.)	99.1° Fahr. (37.3° C.)	99.5° Fahr. (37.5° C.)
Pulse (sitting and tranquil).	75	73	71	78	93
Respirations "	20	20	20	23	25
Weights of ingesta.........	122.99 oz. (3,492.17 gr.)	105.43 oz. (2,987.92 gr.)	86.56 oz. (2,453.67 gr.)	86.19 oz. (2,443.19 gr.)	101.34 oz. (2,872.63 gr.)
Weights of urine and fæces.	44.20 oz. (1,303.08 gr.)	43.73 oz. (1,287.95 gr.)	51.98 oz. (1,531.53 gr.)	36.51 oz. (1,076.50 gr.)	38.83 oz. (1,188.96 gr.)
Estimated cutaneous and pulmonary exhalation	78.79 oz. (2,189.09 gr.)	49.70 oz. (1,354.97 gr.)	54.58 oz. (1,497.14 gr.)	73.58 oz. (2,046.69 gr.)	51.51 oz. (1,366.67 gr.)
Number of hours of sleep...	7 h. 30 m.	6 h. 40 m.	9 h.	7 h. 15 m.	10 h.
Number of miles walked....	15	5	5	15	1

TABLE B[1].

Weights and Analyses of Food and Drink.

First Period—Five Days before the Walk.

	1st Day, Nov. 16th.		2d Day, Nov. 17th.		3d Day, Nov. 18th.		4th Day, Nov. 19th.		5th Day, Nov. 20th.	
	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.
leats ...N. 3.50 p. c.	15.25	233.52	10.50	160.78	10.37	158.79	14.01	214.52	18.25	279.45
ggs.....N. 1.90 "	2.76	22,94	4.14	34.41	2.76	22.94	4.14	34.41	6.90	57.35
filk.....N. 0.66 "	7.21	20.82	4.63	13.37	7.21	20.82	4.38	12.65	11.33	32.71
read....N. 1.08 "	9.88	47.48	8.50	40.16	7.75	36.62	10.25	48.43	8.88	41.96
otatoes.N. 0.33 "	8.25	11.99	10.00	14.44	5.13	7.41	0.88	1.27	3.00	4.33
utter....N. 0.64 "	2.12	5.94	2.95	8.26	3.13	8.76	2.43	6.80	2.75	7.70
offee ...N. 0.11 "	35.60	17.13	32.32	15.53	32.32	15.53	32.32	15.53	32.32	15.53
ea......N. 0.02 "	16.03	1.40	16.03	1.40	16.03	1.40	16.03	1.40	16.03	1.40
on-nitrogenized matters	25.89	..	16.36	..	1.86	..	1.75	..	1.88	..
Total.............	122.99	361.22	105.43	288.35	86.56	272.27	86.19	335.01	101.34	440.43
Total in grammes.	3,492.17	23.404	2,987.92	18.682	2,453.67	17.641	2,443.19	21.706	2,872.63	28.536

Average of five days, quantity of food and drink................ 100.50 oz.

" " " .... 2,848.82 grammes.

" Nitrogen " .... 339.46 grains.

" " " .... 21.994 grammes.

TABLE C[1].

Analyses of Excretions.—Urine and Fæces.

First Period—Five Days before the Walk.

(French weights in parentheses.)

URINE.	1st Day, Nov. 16th.	2d Day, Nov. 17th.	3d Day, Nov. 18th.	4th Day, Nov. 19th.	5th Day, Nov. 20th.	Averages.
Quantity	39.55 fl. oz. (1,170.0 c. c.)	38.03 fl. oz. (1,125.0 c. c.)	46.15 fl. oz. (1,365.0 c. c.)	32.45 fl. oz. (960.0 c. c.)	34.00 fl. oz. (1,050.0 c. c.)	37.84 fl. oz. (1,134.0 c. c.)
Specific gravity	1024.0	1024.4	1023.1	1027.6	1025.2	1024.9
Urea	650.08 grains (42.120)	590.35 grains (38.250)	653.08 grains (42.315)	607.55 grains (39.365)	640.13 grains (41.475)	628.24 grains (40.705)
Nitrogen in urea	303.37 " (19.656)	275.50 " (16.517)	304.77 " (19.747)	283.52 " (18.370)	298.73 " (19.355)	293.18 " (18.729)
Uric acid	3.55 " (0.230)	4.03 " (0.261)	0.94 " (0.061)	1.06 " (0.069)	1.73 " (0.112)	2.26 " (0.127)
Phosphoric acid	51.46 " (3.334)	44.08 " (2.921)	45.14 " (2.925)	67.00 " (4.341)	43.01 " (2.787)	50.14 " (3.262)
Sulphuric acid	38.37 " (2.486)	40.92 " (2.651)	38.86 " (2.518)	51.50 " (3.337)	38.18 " (2.474)	41.57 " (2.693)
Chloride of sodium	195.02 " (12.636)	158.00 " (10.237)	191.70 " (12.421)	106.68 " (6.912)	145.85 " (9.450)	159.45 " (10.331)
Abnormal matters	Large amount of oxalate of lime (octahedra).	Larger amount of oxalate than on Nov. 16th.	Small amount of oxalate.	Large amount of oxalate, with amorphous urates.	Large amount of oxalate.	
FÆCES.						
Quantity	3.70 oz. (105.0)	4.78 oz. (135.5)	4.76 oz. (135.0)	3.17 oz. (90.0)	3.97 oz. (112.5)	4.08 oz. (115.6)
Nitrogen in fæces	19.89 grains (1.289)	25.68 grains (1.664)	25.59 grains (1.658)	17.05 grains (1.105)	21.33 grains (1.382)	21.91 grains (1.421)
Nitrogen in urea and fæces combined	323.26 grains (20.945)	301.18 grains (18.181)	330.36 grains (21.405)	300.57 grains (19.475)	320.06 grains (20.737)	315.09 grains (20.149)
N. of urea & fæces per 100 pts. N. food	89.49	104.45	121.30	89.75	72.67	95.53
Uric acid per 100 pts. of urea	0.538	0.683	0.144	0.174	0.270	0.362

The fæces contained an average of 72 per cent. of water.

TABLE A(2).

Weight, Temperature, Pulse, etc.

Second Period—Five Days of the Walk.

	1st Day, Nov. 21st.	2d Day, Nov. 22d.	3d Day, Nov. 23d.	4th Day, Nov. 24th.	5th Day, Nov. 25th.
Weight of the body	116.5 lbs. (52k. 838gr.)	116.25 lbs. (52k. 724gr.)	Estimated. 115 lbs. (52k. 157gr.)	114 lbs. (51k. 704gr.)	115.75 lbs. (52k. 497gr.)
Temperature under tongue	95.3° Fahr. (35.3° C.)	94.8° Fahr. (34.9° C.)	96.6° Fahr. (35.9° C.)	96.6° Fahr. (35.9° C.)	97.9° Fahr. (36.6° C.)
Pulse (sitting and tranquil)	98	93	109	68	80
Respirations "	20	23	22	18	20
Weights of ingesta	186.25 oz. (5,282.38 gr.)	165.81 oz. (4,700.13 gr.)	171.14 oz. (4,851.22 gr.)	149.07 oz. (4,225.61 gr.)	185.07 oz. (5,246.09 gr.)
Weights of urine and fæces	48.09 oz. (1,416.61 gr.)	42.54 oz. (1,245.73 gr.)	41.88 oz. (1,239.00 gr.)	38.51 oz. (1,136.06 gr.)	49.45 oz. (1,457.15 gr.)
Estimated cutaneous and pulmonary exhalation	181.36 oz. (5,089.78 gr.)	127.27 oz. (3,568.40 gr.)	149.26 oz. (4,179.22 gr.)	126.56 oz. (3,542.55 gr.)	107.62 oz. (2,995.94 gr.)
Number of hours of sleep	1h.	4h. 28m. dozed 5h.	30m.	1h.	9h. 26m.
Number of miles walked	80	48	92	57	40.5
Walking-time	16h. 8m. 3s.	10h. 23m. 33s.	20h. 8m. 43s.	12h. 30m. 34s.	8h. 56m. 36s.
Rate per hour	ab't 5 miles	4.62 miles	ab't 4.5 m'l's	4.5 miles	ab't 4.5 m'ls
Urination	6m. 45s.	2m. 27s.	7m. 47s.	5m. 26s.	4m. 24s.
Defecation	5m. 12s.	6m.	none	3m.	off the track
Rest on the track	1 m.	39m.	1h. 32m. 30s.	41m.	51m.
Rest off the track	7h. 23m.	12h. 49m.	2h. 11m.	14h. 8m.	14h. 8m.

TABLE B(2).

Weights and Analyses of Food and Drink.

Second Period—Five Days of the Walk.

	1st Day, Nov. 21st.		2d Day, Nov. 22d.		3d Day, Nov. 23d.		4th Day, Nov. 24th.		5th Day, Nov. 25th.	
	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.
Meats ... N. 3.50 p. c.	2.00	30.62	6.25	95.70	..	..	1.62	24.81	14.00	214.38
Eggs ..... N. 1.90 "	6.90	57.35	8.28	68.82	8.28	68.82	..	..	4.14	34.41
Milk ..... N. 0.66 "	5.66	16.34	5.66	16.34	6.18	17.84	8.75	25.27	9.78	28.24
Bread .... N. 1.08 "	1.25	5.91	10.50	49.61	1.50	7.09	6.62	31.28	9.00	42.52
Beef-essence .. N. 0.87 "	..	..	..	..	22.26	84.73	10.33	39.32	9.54	36.31
Oatmeal-gruel .. N. 0.086 "	..	..	..	..	6.78	2.55	7.92	2.92	3.39	1.28
Potatoes. N. 0.33 "	..	..	2.00	2.89	..	..	..	..	4.60	5.77
Butter ... N. 0.64 "	2.63	7.36	0.50	1.40	0.50	1.40	..	..	1.25	3.50
Coffee ... N. 0.11 "	67.67	32.57	57.82	27.83	95.95	46.18	38.38	18.47	27.27	13.12
Tea ...... N. 0.02 "	16.03	1.40	38.08	3.33	..	..	30.06	2.63	40.08	3.51
Non-nitrogenized matters	84.11	..	36.72	..	29.69	..	45.39	..	62.62	..
Total	186.25	151.55	165.81	265.92	171.14	228.61	149.07	144.70	185.07	383.04
Total in grammes.	5,282.38	9.820	4,700.13	17.229	4,851.22	14.812	4,225.61	9.3 76	5,246.09	24.818

Average of five days, quantity of food and drink .... 171.47 oz.
" " " .... 4,860.57 grammes.
" Nitrogen " .... 234.76 grains.
" " " .... 13.211 grammes.

TABLE C(2).

Analyses of Excretions.—Urine and Fæces.

Second Period—Five Days of the Walk.

(French weights in parentheses.)

URINE.	1st Day, Nov. 21.	2d Day, Nov. 22.	3d Day, Nov. 23.	4th Day, Nov. 24.	5th Day, Nov. 25.	Averages.
Quantity	42.09 fl. oz. (1,245.0 c. c.)	33.50 fl. oz. (991.0 c. c.)	40.56 fl. oz. (1,200.0 c. c.)	32.52 fl. oz. (965.0 c. c.)	43.60 fl. oz. (1,290.0 c. c.)	38.46 fl. oz. (1,138.0 c. c.)
Specific gravity	1028.6	1030.0	1032.5	1029.6	1022.6	1028.7
Urea	710.00 grains (46.065)	702.86 grains (45.540)	851.95 grains (55.200)	688.98 grains (44.641)	657.02 grains (42.570)	722.16 grains (46.803)
Nitrogen in urea	331.33 " (21.497)	328.00 " (21.252)	397.58 " (25.760)	321.52 " (20.832)	306.61 " (19.866)	337.01 " (21.841)
Uric acid	0.32 " (0.021)	0.14 " (0.009)	4.74 " (0.307)	9.21 " (0.597)	0.57 " (0.037)	3.00 " (0.194)
Phosphoric acid	84.95 " (5.504)	72.14 " (4.674)	102.25 " (6.625)	66.30 " (4.296)	57.49 " (3.725)	76.63 " (4.965)
Sulphuric acid	73.39 " (4.755)	56.90 " (3.687)	63.71 " (4.128)	32.66 " (2.116)	40.84 " (2.646)	53.50 " (3.666)
Chloride of sodium	96.00 " (6.220)	91.68 " (5.940)	44.45 " (2.880)	28.78 " (1.865)	64.50 " (4.179)	65.08 " (4.217)
Abnormal matters	Large amount of oxalate of lime (octahedra).	Same as Nov. 21st.	Very large amount of oxalate.	Small amount of oxalate.	Small am'nt of oxalate, with amorphous phos.	
FÆCES.						
Quantity	4.80 oz. (136.0)	7.94 oz. (225.0)	None	5.03 oz. (142.5)	4.87 oz. (138.0)	4.53 oz. (128.3)
Nitrogen in fæces	25.77 grains (1.670)	42.64 grains (2.763)	"	27.01 grains (1.750)	26.16 grains (1.695)	24.32 grains (1.576)
Nitrogen in urea and fæces combined	357.10 grains (22.167)	370.64 grains (24.015)	397.58 grains (25.760)	348.53 grains (22.582)	332.77 grains (21.561)	361.52 grains (23.217)
Nitrogen of urea and fæces per 100 pts. N. food.	235.63	139.39	173.91	240.86	84.27	174.81
Uric acid per 100 pts. of urea	0.045	0.020	0.556	1.336	0.087	0.409

The fæces contained an average of 72 per cent. of water.

TABLE A(3).

Weight, Temperature, Pulse, etc.

Third Period—Five Days after the Walk.

	1st Day, Nov. 26th.	2d Day, Nov. 27th.	3d Day, Nov. 28th.	4th Day, Nov. 29th.	5th Day, Nov. 30th.
Weight of the body........	118 lbs. (53k. 518gr.)	120.25 lbs. (54k. 539gr.)	120.25 lbs. (54k. 539gr.)	123.5 lbs. (56k. 13gr.)	120.75 lbs. (54k. 765gr.)
Temperature under tongue.	98.6° Fahr. (37° C.)	98.4° Fahr. (36.9° C.)	99.3° Fahr. (37.4° C.)	98.8° Fahr. (37.1° C.)	97.5° Fahr. (36.4° C.)
Pulse (sitting and tranquil).	76	73	70	78	76
Respirations "	22	22	22	24	24
Weights of ingesta.........	129.95 oz. (3,683.63 gr.)	180.61 oz. (5,119.66 gr.)	121.69 oz. (3,449.49 gr.)	188.01 oz. (5,329.43 gr.)	102.67 oz. (2,910.34 gr.)
Weights of urine and fæces.	35.91 oz. (1,061.19 gr.)	51.84 oz. (1,527.81 gr.)	95.37 oz. (2,809.25 gr.)	68.36 oz. (2,013.68 gr.)	77.34 oz. (2,278.72 gr.)
Estimated cutaneous and pulmonary exhalation	58.04 oz. (1,601.44 gr.)	92.77 oz. (2,570.85 gr.)	26.32 oz. (640.24 gr.)	67.65 oz. (1,841.75 gr.)	69.33 oz. (1,879.62 gr.)
Number of hours of sleep...	8h. 20m.	8h. 15m.	8h. 50m.	7h. 35m.	7h. 45m.
Number of miles walked...	2	2	2	2	3

TABLE B(3).

Weights and Analyses of Food and Drink.

Third Period—Five Days after the Walk.

	1st Day, Nov. 26th.		2d Day, Nov. 27th.		3d Day, Nov. 28th.		4th Day, Nov. 29th.		5th Day, Nov. 30th.	
	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains.	Quantity in Oz.	Nitrogen in Grains
Meats ...N. 3.50 p. c.	16.12	246.83	16.50	252.65	9.37	143.48	22.00	336.88	8.25	12[illegible]
Eggs.....N. 1.90 "	4.14	34.41	4.14	34.41	4.14	34.41	4.14	34.41	..	..
Milk.... N. 0.66 "	2.06	5.95	5.14	14.87	9.27	26.76	6.25	18.05	5.66	16[illegible]
Custard..N. 1.28 "	3.25	18.20	..	..	..	..	..	..	..	..
Ice cream N. 1.28 "	3.50	19.60	2.88	16.13	..	..	..	..	..	..
Cream-cakes..N. 1.28 "	..	..	..	..	3.37	18.97	..	..	..	..
Oysters..N. 2.13 "	..	..	3.90	36.34	5.62	53.37	..	..	..	..
Rice-pudding...N. 1.18 "	..	..	..	..	..	..	14.75	77.15	..	..
Head-cheese.N. 2.24 "	..	..	1.50	14.70	..	..	1.00	18.03	..	..
Figs.....N. 0.92 "	..	..	..	..	..	..	2.37	9.54	2.06	8.29
Cheese...N. 4.12 "	..	..	1.13	20.28	1.25	22.53	..	..	..	..
Bread....N. 1.08 "	7.75	36.62	16.15	76.31	11.62	54.80	18.63	88.03	21.00	99.22
Potatoes.N. 0.33 "	5.00	7.22	10.25	14.82	11.00	15.88	13.50	20.59	5.94	8.58
Butter...N. 0.64 "	1.88	5.26	2.75	7.70	2.75	7.70	5.12	14.33	4.12	11.54
Coffee ...N. 0.11 "	24.24	11.56	19.19	9.23	32.32	15.53	48.48	23.30	24.24	11.65
Tea......N. 0.02 "	..	..	19.04	1.66	16.03	1.40	16.03	1.40	16.03	1.40
Non-nitrogenized matters..........	62.01	..	78.04	..	14.95	..	35.74	..	15.37	..
Total.............	129.95	385.65	180.61	499.10	121.69	394.83	188.01	641.71	102.67	283.35
Total in grammes.	3,683.63	24.987	5,119.66	32.338	3,449.49	25.582	5,329.43	41.578	2,910.34	18.359

Average for five days, quantity of food and drink.............. 144.59 oz.
" " " .... 4,098.62 grammes.
" Nitrogen " .... 440.93 grains.
" " " .... 28.569 grammes.

TABLE C(3).

Analyses of Excretions.—Urine and Fæces.

Third Period—Five Days after the Walk.

(French weights in parentheses.)

URINE.	1st Day, Nov. 26.	2d Day, Nov. 27.	3d Day, Nov. 28.	4th Day, Nov. 29.	5th Day, Nov. 30.	Averages.
Quantity	31.59 fl. oz. (937.5 c. c.)	46.14 fl. oz. (1,365.0 c. c.)	84.18 fl. oz. (2,490.0 c. c.)	60.38 fl. oz. (1,786.0 c. c.)	68.39 fl. oz. (2,023.0 c. c.)	58.14 fl. oz. (1,720.3 c. c.)
Specific gravity	1025.8	1024.4	1019.7	1022.5	1022.6	1023.0
Urea	593.23 grains (38.437)	716.29 grains (46.410)	768.61 grains (49.800)	744.32 grains (48.226)	811.48 grains (52.598)	726.79 grains (47.094)
Nitrogen in urea	276.84 " (17.937)	334.27 " (21.658)	358.68 " (23.240)	347.35 " (22.505)	378.69 " (24.546)	339.17 " (21.977)
Uric acid	0.48 " (0.031)	0.52 " (0.034)	0.31 " (0.020)	2.51 " (0.163)	3.30 " (0.214)	1.42 " (0.082)
Phosphoric acid	29.06 " (1.883)	46.93 " (3.041)	105.68 " (6.847)	50.76 " (3.289)	52.00 " (3.364)	56.89 " (3.674)
Sulphuric acid	49.53 " (3.209)	46.07 " (2.985)	53.57 " (3.471)	48.73 " (3.157)	47.20 " (3.058)	49.02 " (3.176)
Chloride of sodium	66.41 " (4.303)	170.64 " (11.056)	622.58 " (40.338)	297.70 " (19.288)	404.65 " (26.218)	312.40 " (20.241)
Abnormal matters	Small amount of oxalate of lime (octahedra), with amorph. urates.	Trace of sugar; small amount of oxalate; uric-acid crystals.	Same as on Nov. 27th.	No abnormal matters.	Moderate amount of oxalate.	
FÆCES.						
Quantity	3.51 oz. (99.5)	4.57 oz. (129.5)	9.53 oz. (270.0)	6.61 oz. (187.5)	7.41 oz. (210.0)	6.33 oz. (179.3)
Nitrogen in fæces	18.86 grains (1.222)	24.54 grains (1.590)	51.19 grains (3.316)	35.54 grains (2.303)	39.80 grains (2.579)	33.99 grains (2.202)
Nitrogen in urea and fæces combined	295.70 grains (19.159)	358.81 grains (23.248)	409.87 grains (26.556)	382.89 grains (24.808)	418.49 grains (27.125)	373.15 grains (24.179)
Nitrogen of urea & fæces per 100 pts. N. of food.	76.68	71.81	103.81	59.67	147.69	91.93
Uric acid per 100 pts. of urea	0.081	0.072	0.040	0.337	0.406	0.187

The fæces contained an average of 72 per cent. of water.

TABLE D.

Daily Averages for the Three Periods.

(French weights and measures in parentheses.)

	First Period—Five Days before the Walk.	Second Period—Five Days of the Walk.	Third Period—Five Days after the Walk.
Weight	Loss in 5 days—21.8 oz. (593 gr.)	Loss in 5 days—55.2 oz. (1,565 gr.) Loss in 4 days—83.2 oz. (2,358 gr.)	Gain in 5 days—80 oz. (2,268 gr.)
	Average of 5 days—	Average of 5 days—	Average of 5 days—
Temperature	99° Fahr. (37.2° C.)	96.3° Fahr. (35.7° C.)	98.6° Fahr. (37° C.)
Pulse	78	90	74
Respirations	22	21	23
Sleep	8 h. 5 m.	3 h. 17 m.	8 h. 29 m.
Miles walked	8.2 miles	63.5 miles	2.2 miles
Ingesta	100.50 oz. (2,848.82 gr.)	171.47 oz. (4,860.57 gr.)	144.59 oz. (4,098.62 gr.)
Nitrogen of food	339.46 grains (21.994)	234.76 grains (13.211)	440.93 grains (28.569)
Cutaneous and pulmonary exhalation	61.63 oz. (1,690.91 gr.)	138.41 oz. (3,875.18 gr.)	62.82 oz. (1,706.78 gr.)
URINE.			
Quantity	37.84 fl. oz. (1,134.0 c. c.)	38.46 fl. oz. (1,138.0 c. c.)	58.14 fl. oz. (1,720.3 c. c.)
Specific gravity	1024.9	1028.7	1023.0
Urea	628.24 grains (40.705)	722.16 grains (46.808)	726.79 grains (47.094)
Nitrogen in urea	293.18 " (18.729)	337.01 " (21.841)	339.17 " (21.977)
Uric acid	2.26 " (0.127)	3.00 " (0.194)	1.42 " (0.082)
Phosphoric acid	50.14 " (3.262)	76.63 " (4.965)	56.89 " (3.674)
Sulphuric acid	41.57 " (2.693)	53.50 " (3.666)	49.02 " (3.176)
Chloride of sodium	159.45 " (10.331)	65.08 " (4.217)	312.40 " (20.241)
FÆCES.			
Quantity	4.08 oz. (115.6)	4.53 oz. (128.3)	6.33 oz. (179.3)
Nitrogen	21.91 grains (1.421)	24.32 grains (1.576)	33.99 grains (2.202)
Nitrogen in urea and fæces combined	315.09 grains (20.149)	361.52 grains (23.217)	373.15 grains (24.179)
Nitrogen of urea and fæces per 100 pts. of Nitrogen of food	95.53 parts	174.81 parts	91.93 parts
Uric acid per 100 pts. of urea	0.362 parts	0.409 parts	0.187 parts

TABLE E.

Meteorological Observations, taken at the Cooper Union, New York City,

BY PROF. ORAN W. MORRIS.

1870. MONTH AND DAY.		BAROMETER. Daily Readings corrected and reduced to 32° Fahr.			THERMOMETER. (Fahrenheit.) Self-registering.				Degree of Humidity, Saturation represented by 100.	WIND. General Direction.		SKY AND ATMOSPHERE.
		Highest.	Lowest.	Mean.	Highest.	Lowest.	Range.	Highest in the sun.		A.M.	P.M.	
Nov.	Date.	in.	in.	in.	°	°	°	°	°			
Wed'day	16	30.065	29.817	29.911	46.0	35.0	11.0	82.0	40.60	N W	S W	Clear.
Thursday	17	30.146	30.059	30.099	47.0	37.0	10.0	78.0	43.16	W	W	Light clouds.
Friday	18	29.931	29.857	29.895	42.0	29.0	13.0	42.5	61.36	S W	W	Slight r'in & slight snow 6.15 P. M.
Saturday	19	29.907	29.735	29.827	36.0	27.0	9.0	42.0	56.66	W	W	Snow sq'lls. Clear eve.
Sunday	20	29.950	29.932	29.942	43.0	33.0	10.0	74.0	43.20	W	S W	Clear A. M.. Cloudy eve
Monday	21	30.167	29.954	30.029	50.0	38.0	12.0	60.0	44.70	S W	W	Cloudy.
Tuesday	22	30.174	29.623	29.913	48.0	39.8	9.0	48.5	73.70	N E	N E	Rain all day. Gale eve.
Wed'day	23	29.763	29.547	29.624	50.0	36.0	14.0	72.0	51.30	S W	W	Light cl'ds.
Thursday	24	29.892	29.832	29.861	44.0	33.0	11.0	77.0	43.46	W	W	Flying cl'ds.
Friday	25	30.044	29.745	29.879	49.0	39.0	10.0	79.3	48.83	W	S W	Clear A. M. Cl'dy & rain 10.15 P. M.
Saturday	26	29.715	29.477	29.569	50.0	40.0	10.0	82.0	63.13	N W	N W	Rain A. M. Light cl'ds.
Sunday	27	29.914	29.803	29.846	58.0	42.0	16.0	89.0	46.40	W	N W	Clear. 2 meteors eve.
Monday	28	30.067	30.054	30.060	58.0	44.0	14.0	90.0	48.90	N W	S W	Light cl'ds.
Tuesday	29	30.033	29.811	29.949	62.0	38.0	24.0	88.5	60.76	S W	N W	Light cl'ds. Slight rain evening.
Wed'day	30	30.277	30.181	30.221	46.0	34.0	12.0	80.0	46.43	N W	S E	Light cl'ds. Clear eve.

The height of the cistern of the barometer is considered to be 46 feet above tide-water.
A severe gale N. E., and very high tide, on the 22d.

PART II.

Physiological Deductions from the Observations taken before, during, and after the Walk of 317½ Miles in Five Consecutive Days.

THE data obtained during the three periods, five days before, five days during, and five days after this remarkable walk, will enable me to come to very definite conclusions with regard to certain physiological questions of interest, particularly the influence of muscular exercise upon the elimination of nitrogen. With regard to the influence of this excessive and prolonged exertion upon the weight of the body, temperature, circulation, respiration, nervous system, etc., the information is necessarily more incomplete and indefinite. I shall, however, endeavor to make use of all of the facts that were noted; though the main object was to study the relations of the nitrogen.

The phenomena observed relate to the weight of the body, and the temperature, pulse, and respirations, in so far as these conditions were modified by the amount of exercise and sleep. Having taken daily the weights of the ingesta, the excretions by the kidneys and intestines, and the weight of the body, it was possible to calculate with tolerable accuracy the amount of exhalation from the lungs and skin.

Weight of the Body.

It is well known that, by regulating the diet and exercise, the weight may be modified within certain limits; and the system of training employed by athletes is supposed to develop to the highest possible extent the muscular power and endurance. The principle in training is, in brief, to regulate the daily exercise, so that gradually the system is worked daily as much as can be endured without exhaustion; and to restrict the diet to rare, lean meats, stale bread, and nitrogenized articles, eliminating fatty matters and reducing the starchy principles to the minimum. By this process, the weight is reduced (for professional athletes out of training are generally over-weight), the muscles are hardened, nearly all the fat disappears, and the power and, within limits, the endurance, are developed to the maximum. In the case of Mr. Weston, no rigid system of training was adopted; but the variations in weight are interesting, in view of the great variations in his diet during the three periods and the immense differences in the amount of exercise taken.

When the investigations were begun, at midnight, November 15th, the weight was 120.5 lbs. (54 k. 655 grammes). At the end of the five days it had been reduced to 119.2 lbs. (54 k. 62 grammes). The lightest weight during this period was on the fourth day, when it was 118.5 lbs. (53 k. 745 grammes). On the second day, the weight increased to 121.25 lbs. (55 kilos.).

First Period, Five Days before the Walk.—On the first day, the weight being unchanged, Mr. Weston walked fifteen miles; he took 122.99 oz. (3,492.17 grammes) of food and drink, containing 361.22 grains (23.404 grammes) of nitrogen. He discharged 44.20 oz. (1,303.08 grammes) in the urine and fæces, and 78.79 oz. (2,189.09 grammes) by the lungs and skin. The weather was clear and dry, the temperature ranging from 35° to 46° Fahr. Assuming the usual quantity of food and drink for an ordinary man to be about 90 oz. (about 2,542 grammes), containing about 310 grains (20 grammes) of nitrogen,[1] rather an excess was taken on this day. The cutaneous exhalation was excessive. Allowing 20 oz. (567 grammes) for pulmonary exhalation, which is tolerably constant, the cutaneous exhalation amounted to 58.70 oz. (1,658.27 grammes), the normal amount being about 30 oz. (850 grammes).[2]

On the second day, there was a diminution in the total quantity of food and drink and in the amount of nitrogen (total food and drink, 105.43 oz. [2,987.92 grammes]; nitrogen, 288.35 grains [18.682 grammes]), with an increase in weight of 12 oz. (345 grammes), the urine and fæces being diminished about 0.5 oz. (15.13 grammes), and the cutaneous exhalation about 29 oz. (834.12 grammes). The weather was a little warmer, but cloudy and damp. The only explanation

[1] FLINT, Jr., *Physiology of Man*, New York, 1867, vol. ii., Alimentation, p. 124.

[2] Id., 1866, vol. i., Respiration, p. 447; and, Id., 1870, vol. iii., Secretion, p. 139.

I can offer for this increase in weight is in the small amount of exercise, which was only five miles.

On the third day, there was a loss of weight amounting to 20 oz. (567 grammes). On this day, there was a further diminution in the quantity of food and drink and in the amount of nitrogen (total food and drink, 86.56 oz. [2,453.67 grammes]; nitrogen 272.27 grains [17.641 grammes]). The urine and fæces were increased about 8.25 oz. (243.58 grammes), and the cutaneous exhalation, 4.88 oz. (142.17 grammes). The exercise was five miles, the same as on the second day.

On the fourth day, the weight was diminished 24 oz. (687 grammes). The total amount of food was about the same as on the third day (86.19 oz.—2,443.19 grammes). The nitrogen was increased by about 63 grains (4.065 grammes). The urine and fæces were diminished by about 15.5 oz. (455.03 grammes), and the cutaneous exhalation was increased by about 19 oz (549.55 grammes). The exercise on this day was fifteen miles· which, with the diminished ingesta, will account for the loss in weight.

On the fifth day, there was a gain in weight of about 11 oz. (317 grammes). The total quantity of food and drink was increased over the amount on the fourth day by about 15 oz. (429.44 grammes). The nitrogen was increased by over 105 grains (6.830 grammes). The urine and fæces were about the same as on the fourth day. The cutaneous exhalation was diminished by 22.27 oz. (680.02 grammes). The exercise on this day was only one mile. The increase in weight is only to be explained by the want of exercise and the large quantity of solid food taken.

Second Period, Five Days of the Walk.—This period presents the greatest interest, as regards the influence of the diet and exercise upon the weight of the body.

On the first day, walking eighty miles and sleeping but one hour, the loss of weight was about 45 oz. (1,224.00 grammes). The quantity of food and drink was increased over the amount on the day before by about 85 oz. (2,409.75 grammes), the increase being chiefly in liquids. The nitrogen was diminished by 289 grains (18,716 grammes). The fæces were but slightly increased. The urine was increased by about 8 oz

(195 c.c.). The estimated cutaneous exhalation was increased by 130 oz. (3,723.11 grammes), a little more than two and a half times. The loss in weight was undoubtedly due, in great measure, to the extraordinary amount of exercise. I will endeavor to explain this more fully when I compare the weights for the three periods.

On the second day, walking forty-eight miles and sleeping 4 hours and 28 minutes, there was a further loss of 4 oz. (114 grammes). The quantity of food and drink was diminished by about 21 oz. (582.25 grammes), but the nitrogen was increased by about 114 grains (7.409 grammes). The fæces were increased by a little more than 3 oz. (89 grammes). The urine was diminished by about 8.5 oz. (254 c.c.). The cutaneous exhalation was diminished by 54 oz. (1,521.38 grammes). The loss of weight I shall endeavor to explain further on.

On the third day, walking ninety-two miles and sleeping but thirty minutes, the loss of weight was estimated at 20 oz. (567 grammes). The weight was not accurately taken on this day, and was averaged.

On the fourth day, walking fifty-seven miles and sleeping one hour, the weight was 36 oz. (1,020.00 grammes) less than on the *second* day. (This represents the loss for two days.) The food and drink were, for the *third* day, about 5 oz. (151.09 grammes) more than for the *second* day, and for the *fourth* day, about 22 oz. (625.61 grammes) less than for the *third* day. On the *third* day, the nitrogen was diminished by about 37 grains (2.417 grammes). On the *fourth* day, the nitrogen was further diminished by 84 grains (5.436 grammes). There were no fæces on the *third* day, and the urine was increased by about 7 oz. (209 c.c.). On the *fourth* day, the fæces were about in average quantity. The urine was diminished about 8 oz. (235 c.c.). On the *third* day, the cutaneous exhalation was increased by about 22 oz. (610.82 grammes). On the *fourth* day, the cutaneous exhalation was diminished by about 23 oz. (636.67 grammes). I shall discuss the loss of weight in connection with a comparison of the three periods.

On the fifth day, walking forty and a half miles, and sleeping 9 hours and 26 minutes, there was an increase in weight of 28 oz. (793.00 grammes). The food and drink were increased by 36 oz. (1,020.48 grammes). The nitrogen was increased by 239 grains (15.442 grammes), about two and two-thirds times. The fæces were diminished 0.16 oz. (4.50 grammes), and the urine was increased, about 11 oz. (325 c.c.). The cutaneous exhalation was diminished about 19 oz. (546.61 grammes).

The loss of weight during this period of extraordinary muscular exertion is a most interesting question; and it will be considered in connection with, not only the amount of food, drink, excretions, and exhalations, but the quantities of nitrogen introduced and discharged.

Third Period, Five Days after the Walk.—It is to be remembered that this period was one of nearly absolute repose, after the immense exertion of the preceding five days, with a daily average of eight and a half hours of sleep.

On the first day, the weight increased by 36 oz. (1,021.00 grammes). The weight of food and drink was diminished by about 55 oz. (1,662.46 grammes), but the amount of nitrogen was about the same as on the fifth day of the second period. The fæces were diminished by 1.36 oz. (38.50 grammes), and the urine, by about 12 oz. (352.50 c.c.). The cutaneous exhalation was diminished by nearly 50 oz. (1,394.50 grammes). The increase in weight was probably due in most part to retention of liquids and appropriation of nitrogenized matter to supply the muscular waste that had been going on for the previous five days. For the five days of the walk, for every 100 parts of nitrogen of food, there was a discharge of 174.81 parts in the urine and fæces. On this, the first day, the discharge of nitrogen was in the proportion of 76.68 parts per 100 parts in the food.

On the second day, there was a further gain in weight of 36 oz. (1,021.00 grammes), which brought the weight to 120.25 lbs. (54 k. 539 grammes), about the standard at the very commencement of the observations, which was 120.5 lbs. (54 k. 655 grammes). The weight of food and drink was increased by 50.66 oz. (1,436.03 grammes), and the nitrogen was increased by about 113 grains (7.351 grammes). The fæces were increased about 1 oz. (28.35 grammes), and the urine about 14.5 oz. (427.15 c. c.). The cutaneous exhalation was increased about

34 oz. (969.41 grammes). This day was warm, clear, and dry, the first day being rainy, and from 5° to 8° Fahr. colder.

On the third day, the weight was unchanged. The food and drink were diminished by 59 oz. (1,670.17 grammes), and the nitrogen, about 104 grains (6.756 grammes). The fæces were increased by 5 oz. (140.5 grammes), a little more than doubled. The urine was increased by 38 oz. (1,125 c.c.), nearly doubled. The cutaneous exhalation was diminished by about 66.5 oz. (1,930.61 grammes), more than three times. This day shows a working off by the urine and fæces of the unusual amount of food, and especially nitrogenized matter, taken on the previous day, the weight remaining stationary.

On the fourth day, the weight was increased 52 oz. (1,474.00 grammes). This great increase is explained by the following circumstance: At 11.15 P. M. Mr. Weston took supper, the food and drink weighing 54.75 oz. (1,547.36 grammes). The weight of the body was taken at 11.55 P. M., about the usual hour. This was the only time when any thing was eaten after 7.45 P. M. This accident renders it useless to discuss the question of weight on this day. On this day, the nitrogen of the food was enormously increased, amounting to 641.71 grains (41,578 grammes); the average for an ordinary man being about 310 grains (20 grammes).

On the fifth day the weight was about the same as on the *third* day; the increase being only 0.5 lbs. (226 grammes). On this, the final day of the observations, the weight was about the same as on the first day of the first period, being increased only a quarter of a pound. The food and drink were diminished about 85 oz. (2,419.09 grammes), and the nitrogen about 358.5 grains (23,219 grammes). The fæces were increased about 1 oz. (22.5 grammes), and the urine 8 oz. (237 c.c.). The cutaneous exhalation was increased about 1.68 oz. (37.87 grammes.)

Causes of the Variations in Weight.[1]—In a measure, the variations in weight during the fifteen days may be satisfactorily explained; but there are certain questions involved that are as yet obscure. The explanation of the variations during

[1] To avoid complicating the discussion of the causes of the variations in weight, the English weights only will be used.

the walk, and for the five days after, is much facilitated by a comparison of the ingress and egress of nitrogen.

At the outset of the investigations, the weight was 120.5 lbs., which Mr. Weston thought was about normal. During the period of five days before the walk, the variations were not very great, the highest being 12 oz. above, and the lowest 32 oz. below. At the end of the fifth day, the weight was reduced by about 21 oz. On the first day, the weight being unchanged, the exercise was fifteen miles. The food was of the ordinary variety, but its quantity and proportion of nitrogen were about 30 per cent. above the average for an ordinary man. On the second day, the diminished exercise, the food being less, but still above the normal average, will account for the increase in weight of 12 oz. On the third day, the exercise was the same as on the second day, but the food was reduced a little below the normal average, which will account for 20 oz. loss of weight. On the fourth day, the food was still below the average, being about the same as on the previous day, but it contained a large proportion of nitrogenized matter, over 20 per cent. more than on the third day. The exercise was fifteen miles, which, with the diet, will account for 24 oz. loss of weight. On the fifth day, the food was increased to a little above the average, and it contained an immense amount of nitrogen, about 35 per cent. above the average. This fact, with the absolute muscular repose and ten hours' sleep, as a preparation for the walk, will readily account for 11 oz. increase in weight. During this period of five days before the walk, the average quantity of food and drink was 100.5 oz., containing 339.46 grains of nitrogen, the ordinary average being 90 oz., containing 310 grains of nitrogen. The average discharge of nitrogen by the urine and fæces was 95.53 parts per 100 parts of the nitrogen of food; which is about normal. It is thus evident that the variations in weight during a period of five days of ordinary life can be readily explained in accordance with generally-accepted physiological principles.

In endeavoring to explain the variations in weight that occurred during the walk, and for the succeeding five days, the extraordinary amount of muscular exertion introduces new elements to be considered. These have a most important bearing upon the subject of nutrition, disassimilation, and "the source of muscular power," about which so much has been written within the past few years.

First: What tissue was consumed, the products being thrown off, during the effort of walking 317½ miles in five consecutive days? Was it the muscular substance? The importance, as regards our ideas of nutrition, of a positive and definite answer to this question can hardly be overestimated.

The loss of weight was undoubtedly due in a great measure to the excessive muscular exertion; but in part, also, to change in diet. This proposition does not demand discussion.

The loss must have been either in liquids, fats, or muscular substance.

It is not probable that the loss was due, to any great extent, to a diminution in the proportion of liquids, for the excessive loss from the skin was instantly supplied by liquids taken into the stomach. It is not necessary to cite experiments which show that loss by the skin, as it occurs in hot-air or vapor-baths, or in working for an hour or more at a high temperature, is readily compensated by liquid ingesta, as this fact is well settled in physiology.[1] A glance at the daily tables of food and drink will show that, during the five days of the walk, Mr. Weston took from 8 lbs. 8 oz. to 10 lbs. 11 oz. of liquids.

If the loss were due to a consumption of non-nitrogenized matters, it would be chiefly of fat and would be represented by the carbonic acid of expiration. It is certain that the non-nitrogenized constituents of the body do not contribute to the formation of the nitrogenized excrementitious matters.

If the loss were due to a consumption of the nitrogenized elements of the body, principally of the muscular tissue, this loss, under the extraordinary muscular effort, would be represented by the nitrogen of the excretions. It is not probable that the nitrogenized constituents of the body are, in any considerable amount, changed into non-nitrogenized matter and exhaled under the form of carbonic acid, though this may occur to a slight extent.

[1] See my work on Physiology, New York, 1870, vol. iii., p. 140, *et seq.*

The question then resolves itself to that of the relative consumption and elimination of nitrogenized matters. The following are the facts on this point, observed during the five days of the walk:

During the five days of the walk[1] Mr. Weston consumed in all, 1,173.80 grains (76.055 grammes) of nitrogen in his food. During the same period, he eliminated 1,807.60 grains (116.084 grammes) of nitrogen in the urine and fæces. This leaves 633.80 grains (40.030 grammes) of nitrogen, over and above the nitrogen of the food, which must be attributed to the waste of his tissues, and probably almost exclusively to the waste of his muscular tissue. According to the best authorities, lean meat, uncooked, or muscular tissue, contains 3 per cent. of nitrogen.[2] The loss of 633.80 grains (40.030 grammes) of nitrogen, would then represent a loss of 21,127.00 grains (1,334.33 grammes), or 3.018 lbs. of muscular tissue. The actual loss of weight was 3.450 lbs. (1,565.00 grammes). This allows about 0.43 lb. (230.67 grammes) loss unaccounted for, which might be fat or water.

The correspondence of these figures of loss calculated from the amount of nitrogen eliminated with the actual loss in weight leaves no room for doubt with regard to the fact that the immense exertion during this period of five days was attended with consumption of the muscular substance. Those who have adopted the view that the muscular system is like a steam-engine, consuming in its work food as fuel and not its own substance, may say that this is an extraordinary case, as it undoubtedly is; but the facts developed by the foregoing observations prove, none the less conclusively, that the muscular system may consume its own substance by exercise, even when the individual takes all the food required by his appetite. It can hardly be, however, that the foregoing facts are not in accordance with a general physiological law.

It will be interesting, now, to study the behavior of the system after the walk, when there was almost absolute repose,

[1] I have reduced these calculations, on account of their great importance, to grammes.

[2] Payen, *Précis théorique et pratique des substances alimentaires*, Paris, 1865, p. 488.

and when the quantity of nitrogen taken with the food was largely increased. The important question here is the following:

In the return of the weight to the normal standard, did the muscular tissue take up nitrogen to repair the excessive waste engendered by the five days of exertion?

In two days after the walk, the weight had increased to within four ounces of the standard at the beginning of the observations, five days before the walk. It is not to be expected that this increase would be due entirely to appropriation of nitrogenized matter by the muscular system. Reference to the tables of diet for these two days shows that the food taken was about 155 oz. each day, the normal average being assumed at 90 oz., an excess of a little more than 70 per cent. The nitrogen taken was about 50 per cent. in excess of the normal amount. The tables also show a large proportion of non-nitrogenized matter in the food on those days. The exercise was only two miles daily. Mr. Weston gained in weight 4.5 lbs. He retained in his system an amount of nitrogen equivalent to 1.1 lb. In view of the muscular inactivity and the large proportion of non-nitrogenized matter in the food, it is fair to assume that the remaining 3.4 lbs. was due to accumulation of fat. This, however, is a point incapable of positive demonstration. Taking the entire period of five days after the walk, the gain in weight was five pounds, which brought it 4 oz. above the weight at the beginning of the fifteen days. The excess of the nitrogen of food over the nitrogen of the urine and fæces represented, for these five days, an accumulation of 1.6 lb. of muscular substance. During this time there was almost complete repose of the muscular system. The daily quantity of food was about 61 per cent. over the normal average, and the nitrogen, about 42 per cent. over the average. The food contained, also, a large proportion of non-nitrogenized matter.

These facts seem to indicate that, after the immense effort in walking 317½ miles in five consecutive days, for five days of muscular inactivity, the quantity of food being large and containing a greater proportion of non-nitrogenized matter than the food taken either before or during the walk, the muscular system appropriated 1.6 lb. of nitrogenized matter, and the entire body accumulated about 3.4 lbs. of fat. It is well known that athletes, after a season of severe training by exercise and nitrogenized diet, accumulate fat very rapidly, when the muscles are allowed repose and the diet is unrestricted.

Temperature, Pulse, and Respirations.

The temperature under the tongue for every day during the three periods was carefully taken, as nearly as possible at the same hour and under the same conditions. During the five days of the walk, the temperature was taken after the day's walk had been accomplished; and during the five days before and the five days after the walk, it was taken generally between 10.45 P. M. and midnight.

First Period, Five Days before the Walk. — The temperatures for each day do not present any great range of variation. The data here are chiefly useful as indicating the normal average under ordinary conditions. The highest temperature was at the end of the first day. It was then 99.7° Fahr. (37.6° C.). The lowest temperature was on the third day, when it was 98° Fahr. (36.7° C.). On the first day, the quantity of food and drink and the proportion of nitrogen were above the average, by about 20 per cent. The exercise was fifteen miles. On the third day, the quantity of food and drink was a very little below the average, and less nitrogen was taken than on any of the five days. The exercise was five miles. On the fifth day, the temperature was within 0.2° Fahr. of the temperature on the first day. On this day the quantity of food and drink was slightly above the average, but the nitrogen of the food was increased 42 per cent. The exercise was only one mile. On the first day, the weather was clear, the highest temperature in the shade was 46°, and the lowest, 35° Fahr. On the fifth day, it was also clear, and the highest temperature was 43°, and the lowest, 30° Fahr. On the third day, the meteorological record was, "slight rain and slight snow 6.15 P. M.," highest temperature 42°, and lowest 29° Fahr. On the fourth day, when the temperature under the tongue was 99.1° Fahr. (37.3° C.), the external temperature was 36°, highest, and 27°, lowest, "snow-squalls, clear evening." On this day, the total amount of food and drink was the same as on the third day, but the nitrogen of the food was increased by about 23 per cent. The exercise was fifteen miles, on the fourth day. On the second day, when the temperature under the tongue was 98.4° Fahr. (36.9° C.), the nitrogen of the food was only 16.08 grains more than on the third day. The weather was cloudy, the highest temperature, 47°, and the lowest, 37° Fahr.

In the range of temperature during the five days of this period, there does not seem to be any marked difference due to the exercise. The variations apparently bear some relation to the amount of nitrogenized food, the temperature being high when the nitrogen of the food is abundant, and low when the proportion is small. The temperature was markedly higher on the clear days, without any definite relation to the external temperature.

The range of temperature for these five days was about normal, from 98° to 99.7° Fahr. (36.7° to 37.6° C.). In my work on physiology, I have taken, as the standard temperature under the tongue, 98° Fahr., subject to variation within the limits of health of about 0.5° below and 1.5° above.[1]

The average temperature for the first period of five days before the walk, which I shall take as the standard for comparison with the temperatures at the other periods, is 99° Fahr. (37.2° C.).

Second Period, Five Days of the Walk.—The variations in temperature during this period are remarkable, and highly interesting from their possible physiological relations. By reference to the meteorological table (E.), it will be seen that the weather during this period was generally cloudy, without much variation from day to day in the thermometer. There does not appear to be any constant relation, during this period, between the temperature and the daily consumption of nitrogen.

On the first day, between 12.15 A. M. and 10.32½ P. M. Mr. Weston walked eighty miles. His temperature was taken

[1] FLINT, Jr., *Physiology of Man*, New York, 1870, vol. iii., Nutrition, p. 396.

eight minutes after he had completed the walk, and was 95.3° Fahr. (35.3° C.), 4.3° less than the last temperature taken before the walk was begun. This is an immense reduction, greater than ever occurs under the ordinary conditions of health, and can be attributed only to the extraordinary muscular exertion during the day.

On the second day, between 4.58 A. M. and 4.5 P. M., Mr. Weston walked forty miles, when he stopped for 6 hours and 19 minutes. At 10 P. M., about six hours after the stop, the temperature was 94.8° Fahr. (34.9° C.), a reduction from the temperature of the first day of 0.5°. Mr. Weston did not sleep well, as he had hoped to do during the six hours. At 10.24 P. M., he began his first effort to walk one hundred and twelve miles in twenty-four consecutive hours. I now think the further lowering in the temperature was an indication of want of proper reaction after the walks he had already accomplished. Had I appreciated the facts at that time, I would have advised him to have deferred his first attempt to accomplish the hundred and twelve miles until a later period. As it was, the attempt was a failure.

As on the first day, the lowering in temperature is only to be attributed to the excessive and prolonged muscular exertion.

On the third day, between midnight of the second day and 10.52 P. M., Mr. Weston walked ninety-two miles. At 11.15 P. M. the temperature was 96.6° Fahr. (35.9° C.), 1.8° higher than on the second day.

On the fourth day, Mr. Weston walked fifty-seven miles between 1.33 A. M. and 10.30 P. M. The temperature, taken at 10.40 P. M., was 96.6° Fahr. (35.9° C.), the same as on the third day. This was the day on which the walk was interrupted by nervous prostration.

On the fifth day, Mr. Weston walked forty and a half miles, between 9.56 A. M. and midnight. He continued walking for fifteen minutes after midnight. He was in fine spirits all day. During this twenty-four hours, for the first time, he got sufficient refreshing sleep. He slept nine hours and twenty-six minutes. The temperature, taken at 1.30 A. M. of the next day, was 97.9° Fahr. (36.6° C.); an increase of 1.3° over the temperature of the day before.

It is difficult to explain satisfactorily the elevation of temperature by 1.8° on the third day, the day of the longest walk, and the same temperature on the fourth day, when Mr. Weston broke down completely. The temperature, however, on these days was still 2.4° below the average of the five days before the walk, and 2° below the average of the five days after the walk. The elevation of temperature on the fifth day, by 1.3°, was probably on account of the sleep of nine hours and twenty-six minutes.

The average temperature during this period was 96.3° Fahr. (35.7° C.); 2.7° below the average of five days before, and 2.3° below the average of five days after the walk. The tolerably uniform depression of temperature during this period of excessive exertion shows pretty conclusively that severe and prolonged muscular exercise diminishes the heat of the body. It has been observed that during, or immediately after moderate exercise, the heat of the body is increased, and that the actual temperature of the muscles is sensibly elevated;[1] but this is very different from the immense muscular and nervous strain to which Mr. Weston subjected himself for five days. The fact of diminution of temperature during this period remains, without any explanation, except that it was probably due to some unusual condition of the nervous system.

Third Period, Five Days after the Walk.—During this period, there was but little variation in the temperature from day to day. On the first day, the temperature was 98.6° Fahr. (37° C.); 0.7° higher than on the last day of the walk. This temperature was about normal. On the second day, the temperature was 98.4° Fahr. (36.9° C.); on the third day, 99.3° Fahr. (37.4 C.); on the fourth day, 98.8° Fahr. (37.1° C.); and on the fifth day, 97.5° Fahr. (36.4° C.). This range of temperature was about normal, assuming, as I have done, that the average is 98° Fahr., with a range of 0.5° below and 1.5° above. The average temperature for the five days was 98.6 Fahr. (37° C.), 0.4° less than the average for the five

[1] For an account of different observations on this point, see my work on Physiology, New York, 1870, vol. iii, Nutrition, p. 413.

days before the walk, and 2.3° more than the average for the five days of the walk.

In studying the variations in temperature from day to day during this period, I have not been able to establish any definite relation with the food or with the meteorological record. The difference between the average during this period and the average for the five days before the walk is insignificant. It is interesting to note, however, that as soon as the extraordinary muscular effort ceased, the temperature returned to about the normal standard.

Pulse and Respirations.—During the first period, there was very little variation in either the pulse or respirations. The extremes for the pulse were 93 and 71. The pulse was 93 just before the walk, and this was undoubtedly due to the excitement incident to the commencement of the trial. At that time, also, the respirations were 25. For the first three days, the respirations were 20, and on the fourth day, 23.

During the five days of the walk, the pulse ranged from 68 to 109. The pulse was 109 on the third day, when the exercise was ninety-two miles. The range of the respirations was from 18 to 23. On the fourth day, after Mr. Weston had completely broken down in his walk, the pulse was 68, and the respirations, 18.

For the five after the walk, the range of the pulse was from 70 to 78, and the respirations were from 22 to 24.

The averages for the five days before the walk were, for the pulse, 78, respirations, 22; for the five days of the walk, pulse 90, respirations, 21; and for the five days after the walk, pulse 74, respirations, 23.

In the absence of sphygmographic records of the pulse, there could be very little learned from the observations on the circulation. The variations in the respirations, also, convey very little information. It was impossible, however, to make the records on these points more elaborate; and as it was necessary to make all of the observations without subjecting Mr. Weston to any considerable annoyance or loss of time, experiments with the sphygmograph would have been impracticable.

The records with regard to sleep, exercise, quantity of food and drink, and the composition of the food, were made to be used in connection with the question of the elimination of nitrogen, and will not, therefore, be discussed separately. The cutaneous and pulmonary exhalations were calculated from the weight of ingesta, urine, and fæces, and the variations in the weight of the body. As these were not directly estimated, they will not be discussed under distinct heads.

Variations in the Urine due to Exercise, studied in connection with the Proportion of Nitrogen in the Food.

In discussing the variations in the urine during the three periods into which the investigations were divided, I shall take up first the quantity; then the urea, or the amount of nitrogen eliminated in the urea, in connection with the nitrogen of the fæces, and compare the total elimination of nitrogen with the quantity introduced with the food; then the uric acid and its relations to the urea; and, finally, the inorganic salts and abnormal matters.

Quantity of Urine.

The most important point to determine in this connection is whether the immense amount of exercise during the five days of the walk had any influence upon the elimination of water by the kidneys. This can be settled with tolerable accuracy, inasmuch as the liquids taken each day were carefully measured.

First Period, Five Days before the Walk.—The range of variation in the quantity of urine during this period was not great, the extremes being 32.45 fl ℥ (960 c. c.), and 46.15 fl ℥ (1,365 c. c.). The variations do not present any definite relation to the quantity of liquids. On the fourth day, with 32.45 fl ℥ of urine, the liquids taken amounted to 68.73 fl ℥. On the third day, with 46.15 fl ℥ of urine, the liquids taken amounted to 55.56 fl ℥. On the third day, when the quantity of urine was the greatest, the meteorological record is the following: Thermometer, highest, 42° Fahr., lowest, 29° Fahr.; humidity (saturation 100) 61.36; "slight rain and slight snow at 6.15, P. M." The humidity on that day was the greatest of the five. On the fourth day, when the quantity of urine was the least, the record was as follows: Thermometer, highest, 36° Fahr., lowest, 27° Fahr.; humidity 56.66; "snow-squalls, clear evening." During this period, the excess of liquids taken must have been discharged through the skin.

The average quantity of urine during these five days was 37.84 fl ℥ (1,134 c. c.). The average quantity of liquids taken daily was 65.56 fl ℥ (1,966.8 c. c.).

Second Period, Five Days of the Walk.—The range of variation in the quantity of urine during this period was also slight, the extremes being 43.60 fl ℥ (1,290 c. c.), on the fifth day, and 32.52 fl ℥ (965 c. c.), on the fourth day. The variations bore no definite relation to the meteorological record. On the day of greatest discharge of urine, the liquids taken amounted to 151.06 fl ℥. On the day of the least urine, the liquids taken amounted to 137.04 fl ℥. During this period, the relations between the quantity of urine and of liquids taken were pretty constant: first day, urine, 42.09 fl ℥, liquids taken, 171.67 fl ℥; second day, urine, 33.50 fl ℥, liquids taken, 136.40 fl ℥; third day, urine, 40.56 fl ℥, liquids taken, 158.75 fl ℥; fourth day, urine, 32.52 fl ℥, liquids taken, 137.04 fl ℥; fifth day, urine, 43.60 fl ℥, liquids taken, 151.06 fl ℥.

The average quantity of urine during these five days was 38.46 fl ℥ (1,138 c. c.). The average quantity of liquids taken was 150.40 fl ℥ (4,512 c. c.).

The average of 38.46 fl ℥ (1,138 c. c.) for the five days of the walk, against 38.14 fl ℥ (1,134 c. c.), for the five days before the walk, shows conclusively that the walk of 317½ miles in five days did not affect the quantity of urine; and that the immense amount of liquids taken during that time must have been discharged by the skin.

Third Period, Five Days after the Walk.—The variations in the daily discharge of urine during this period were very considerable, the extremes being 84.18 fl ℥ (2,490 c. c.), on the third day, and 31.59 fl ℥ (937.5 c. c.), on the first day. The variations bore no definite relation to the meteorological record. There was no definite relation between the quantity of urine and the liquid ingesta. On the third day, with 84.18 fl ℥ of urine, the liquids taken amounted to 57.87 fl ℥;

and on the first day, with 31.59 fl ℥ of urine, the liquids taken amounted to 46.74 fl ℥. On the second day, the liquids taken amounted to 104.82 fl ℥, and the urine discharged, 46.14 fl ℥.

The average quantity of urine during these five days was 58.14 fl ℥ (1,720 c. c.). The average quantity of liquids taken was 69.22 fl ℥ (2,076.6 c. c.).

During the five days after the walk, for every 100 parts of liquid ingesta, the kidneys discharged 84 parts. During the five days before the walk, for every 100 parts of liquid ingesta, the kidneys discharged 58 parts. This is probably to be explained by the exercise of 8.2 miles daily for the five days before the walk, which would increase the action of the skin, while after the walk, the exercise was only 2.2 miles daily.

It will not be necessary to consider under a separate head the variations in the specific gravity of the urine, as this simply represents the solid constituents, which will be taken up separately.

Influence of Exercise upon the Elimination of Nitrogen, chiefly in the Urea, and the Relations between the Nitrogen discharged and the Nitrogen ingested.

As regards the elimination of nitrogen, the investigations were undertaken chiefly with reference to the influence of the great amount of muscular exertion during the five days of the walk. In order to ascertain exactly the amount of nitrogen excreted at this time, as compared with that discharged under ordinary conditions, the nitrogen of both the urea and fæces was taken. The proportion of nitrogen in the uric acid, cretine and creatinine of the urine is so insignificant, as compared with the total discharge, that it would hardly at all modify the results of the calculations. During the fifteen days, Mr. Weston took food according to his fancy. At certain times during the walk, he took immense quantities of tea and coffee; but the results of the calculations show that the modifications, if any, in the discharge of urea produced by those articles, must have been greatly overshadowed by those due to the muscular exertion. In the discussion of this, the most interesting and important of all the questions involved, the influence of food will be treated of from a secondary point of view. As regards this point, there is no difference of opinion. Nitrogenized food always increases the elimination of urea; and so marked is this, that many physiologists hold the view that the urea is derived almost entirely from the food. This is one of the physiological questions definitively settled by these observations.

From the foregoing considerations, it is evident that the only rigidly accurate way to determine exactly the modifications in the elimination of nitrogen that are to be attributed to muscular exercise, is to calculate for each period, and for every day of each period, the proportion borne by the nitrogen in the urea and fæces to the nitrogen of the food. It is true that the influence of the food of one day may be prolonged for one or more days, and the same remark may possibly apply to the exercise; but the periods of five days each are sufficiently long to obviate any serious error from this cause. I have learned, however, from these calculations, that a period much shorter would not be entirely satisfactory.

The conclusions that I shall arrive at will all be drawn from Tables A.(1) B.(1) C.(1) for the first period, Tables A.(2) B.(2) C.(2) for the second period, and Tables A.(3) B.(3) C.(3) for the third period. Table D. gives the daily averages for the three periods.

First Period, Five Days before the Walk.—For the first day of this period, the total nitrogen of the urea and fæces amounted to 323.26 grains (20.945 grammes). The nitrogen of the food amounted to 361.22 grains (23.404 grammes). For every 100 parts of nitrogen of food, there were discharged in the urea and fæces, 89.49 parts. The exercise was fifteen miles. The nitrogen of the food was about 30 per cent. above the average for an ordinary man. The elimination of nitrogen per 100 parts of the nitrogen of food was considerably below the average.

On the second day, the total nitrogen of the urea and fæces was 301.18 grains (18.181 grammes). The nitrogen of the food amounted to 288.35 grains (18.682 grammes). For every 100 parts of nitrogen of food, there were discharged in the urea and fæces, 104.45 parts. The exercise was five miles. The nitrogen of the food of this day was a little below the average.

On the third day, the total nitrogen of the urea and fæces was 330.36 grains (21.405 grammes). The nitrogen of the food amounted to 272.27 grains (17.641 grammes), much below the average for an ordinary man, which I put at 310 grains. For every 100 parts of nitrogen of food, there were discharged in the urea and fæces, 121.3 parts. The exercise was five miles.

On the fourth day, the total nitrogen of the urea and fæces was 300.57 grains (19.475 grammes). The nitrogen in the food amounted to 335.01 grains (21.706 grammes), a little above the average for an ordinary man. For every 100 parts of nitrogen of food, there were discharged in the urea and fæces, 89.75 parts. The exercise was fifteen miles.

On the fifth day, the total nitrogen of the urea and fæces was 320.06 grains (20.737 grammes). The nitrogen of the food amounted to 440.43 grains (28.536 grammes), very much above the average. For every 100 parts of nitrogen of food, there were excreted in the urea and fæces, 72.67 parts. The exercise was one mile, with ten hours' sleep.

Taking the averages for the five days, the nitrogen of the urea and fæces daily was 315.09 grains (20.149 grammes). The daily nitrogen of the food amounted to 339.46 grains (21.994 grammes). For every 100 parts of nitrogen of food, there were excreted in the urea and fæces, 95.53 parts, which may be taken as the normal average under ordinary conditions.

From these figures, the following important conclusions may be drawn:

1. Under ordinary conditions, about 95 per cent. of the nitrogen of food is represented in the urea and fæces, the remaining 5 per cent. may be put down to nitrogen discharged in other ways, and to an allowance for error in the estimates, particularly in the food.

2. In view of the extraordinary powers of endurance of Mr. Weston and his habit of walking long distances, I do not think that the variations in the amount of exercise during the five days are to be regarded as sufficient to influence, to any great extent, the elimination of nitrogen; and I consider that

these variations are chiefly due to the nitrogen of the ingesta. The influence of the food is undoubtedly manifested in a more marked manner one or two days after, than on the day on which the excess of nitrogen is taken. This fact has been recognized by physiologists, especially since the researches of Lehmann, to which reference has already been made.[1] On the first day, there was about 30 per cent. of excess of nitrogen in the food, and 89.49 parts of nitrogen discharged per 100 parts of nitrogen taken in. On the second and the third day, the nitrogen of the food was a little below the average. On these days, there was an average of 112.87 parts of nitrogen discharged per 100 parts of nitrogen taken in. On the fourth day, the nitrogen of the food was slightly in excess, with 89.75 parts per 100 discharged. On the fifth day, the nitrogen in the food was very largely in excess (42 per cent.), with 72.67 parts per 100 discharged. The absolute quantity of nitrogen discharged on the fifth day was large, but the proportion per 100 of the nitrogen of food was overbalanced by the immense quantity introduced.

What is the mechanism of the influence of nitrogenized food upon the discharge of nitrogen by the excretions? Does the excremental nitrogen come from a direct change of the nitrogenized constituents of the blood into urea in the blood itself, or is it derived from the nitrogenized food used, through the blood, in building up the nitrogenized semi-solids of the body, passing into the excretions through the processes of nutrition and disassimilation?

Although the answer to this question is, perhaps, beyond the limits of actual demonstration, the attainable facts point very strongly to the following solution:

The nitrogenized food occupies several hours in its digestion and appropriation by the blood, where it is changed into the nitrogenized nutritive principles of the circulating fluid. The process of its appropriation by the nitrogenized elements of the tissues, particularly the muscular system, is probably slower still. The chief product of disassimilation of the nitrogenized elements of the tissues is urea; and its separation is very slow and gradual, part of it being taken up from the tissues

[1] LEHMANN, *Physiological Chemistry*, Philadelphia, 1855, vol. i., p. 150.

directly by the blood, and part passing into the blood by the lymph. This fact is illustrated by the slow accumulation of urea in the blood after extirpation of the kidneys. If this be the mechanism of the production of urea, the increase in its quantity would be marked for a day or two after the introduction of an excess of nitrogenized food, which is a fact sufficiently well demonstrated by actual observation. If the excess of urea were directly formed in the blood from an excess of nitrogenized food, being discharged by the urine and leaving a stated and but slightly variable amount resulting from the actual disassimilation of the tissues, its increased discharge from an excess of nitrogenized food would be more rapidly developed.

Second Period, Five Days of the Walk.—On the first day of this period, Mr. Weston walked eighty miles, with one hour of sleep. The total nitrogen of the urea and fæces amounted to 357.10 grains (22.167 grammes). The nitrogen of the food was reduced more than 50 per cent. below the average, amounting to only 151.55 grains (9.820 grammes). For every 100 parts of nitrogen introduced, there were 235.63 parts of nitrogen discharged.

This enormous discharge of nitrogen, in proportion to the nitrogen of the food, may be in part explained by the large excess of nitrogen taken the day before; but by far the greatest part can be attributed only to the extraordinary muscular exertion and the consequent waste of the muscular tissue. The loss of weight on the first day was 43.2 oz. (1,224.00 grammes.)

On the second day, Mr. Weston walked forty-eight miles, with 4 hours and 28 minutes of sleep. The total nitrogen of the urea and fæces amounted to 370.64 grains (24.015 grammes). The nitrogen of the food was largely increased, amounting to 265.92 grains (17.229 grammes). For every 100 parts of nitrogen introduced, there were discharged, 139.39 parts. On this day, there was still a large excess of nitrogen discharged; but the proportion per 100 parts of the nitrogen introduced was reduced by the increase in the proportion in the food. The excessive discharge of nitrogen on this day is to be attributed almost exclusively to the muscular exertion of that, and, perhaps, of the previous day.

On the third day, Mr. Weston walked ninety-two miles, with 30 minutes' sleep. The entire quantity of nitrogen of the urea (no fæces were passed) was enormous, amounting to 397.58 grains (25.760 grammes, representing 851.95 grains (55.200 grammes) of urea, by far the largest amount discharged for any one of the five days. This corresponded to the greatest amount of muscular exertion, a fact which is very significant. The nitrogen of the food was slightly diminished, amounting to 228.61 grains (14.812 grammes). For every 100 parts of nitrogen introduced, there were discharged, 173.91 parts. This excessive discharge of nitrogen can only be attributed to the muscular exertion. On that day, Mr. Weston took six pints of strong coffee, which, if it had any effect, would have diminished the elimination of urea.

On the fourth day, Mr. Weston walked fifty-seven miles, with one hour of sleep. The nitrogen of the urea and fæces amounted to 348.53 grains (22.582 grammes). The nitrogen of the food was on this day diminished to the minimum, amounting to only 144.70 grains (9.376 grammes). For every 100 parts of nitrogen introduced, there were discharged, 240.86 parts, the largest excess observed during the five days.

At 10.30 P. M., on this day, Mr. Weston broke down completely. He could not see the track, and was taken staggering to his room, having reached, apparently, the limit of his endurance. His condition at that time, as shown by the records, was as follows: He had lost in weight 83.2 oz. (2,358.00 grammes), being reduced from 119.2 lbs. (54 k. 62 grammes) to 114 lbs. (51 k. 704 grammes). He had taken a daily average of 197.70 grains (12.809 grammes) of nitrogen in his food, while walking an average of sixty-nine and a quarter miles per diem, with an average of sleep in the twenty-four hours of 1 hour and 44 minutes, for four days. His daily average of nitrogen should have been 310 grains (about 20 grammes), not allowing for an increased quantity demanded to supply the waste engendered by his excessive muscular exertion. He had discharged for every 100 parts of nitrogen introduced, a daily average of 197.45 parts, nearly double, for four days. The calculations, as well as the general condition of the system, show that the period had probably arrived when repair of the muscular substance had become absolutely necessary.

If these facts be accepted, and, leaving the widest margin for inaccuracy in the estimates, they cannot involve any considerable error, it is impossible to come to any other conclusion than that excessive and prolonged muscular exertion increases enormously the excretion of nitrogen, and that the excess of nitrogen discharged is due to an increased disassimilation of the muscular substance; and it is to be remembered that the experiments upon which this statement is based were made with a diet regulated solely by the taste of the individual under observation.

On the fifth day, after 9 hours and 26 minutes of sleep, the system reacted completely, and Mr. Weston walked forty and a half miles. The nitrogen of the urea and fæces was 332.77 grains (21.561 grammes). The nitrogen of the food was increased 165 per cent., amounting to 383.04 grains (24.818 grammes). For every 100 parts of nitrogen of food, there were discharged, 84.27 parts. The absolute quantity of nitrogen discharged was still very great, but the proportion to the nitrogen introduced was reduced by the great quantity in the food.

On this day, when there was apparent reaction after the complete prostration of the fourth day, the system seemed to appropriate nitrogen, as it were, with avidity, to repair the impoverished muscular tissue. The weight was increased on this day by 28 oz. (793 grammes).

A study of the averages for the five days of this period develops points of great interest and importance, some of which have already been considered in connection with the variations in weight:

First. The absolute discharge of nitrogen by the urea and fæces for each day, without considering the nitrogen of the food, is in a nearly uniform proportion to the number of miles walked. This proportion is but little disturbed, if it be assumed that the influence of the ingestion of nitrogen is prolonged for a period of from twenty-four to forty-eight hours.

Second. During the walk of 317½ miles in five consecutive days, for every 100 parts of nitrogen taken in with the food, there were discharged in the urea and fæces, 174.81

parts, against 95.53 parts per 100 for the five days before the walk, and 91.93 parts per 100 for the five days after the walk.

Third. The actual loss of weight during the five days of the walk, was 3.450 lbs. (1,565.00 grammes). The total quantity of nitrogen discharged in the urea and fæces during this period, in excess of the nitrogen taken in with the food, was 633.80 grains (40.030 grammes). Assuming that 3 parts of this nitrogen represents the waste of 100 parts of muscular tissue, the loss of muscular tissue calculated from the nitrogen excreted would amount to 3.018 lbs. (1,334.33 grammes), leaving only 0.43 of a pound (230.67 grammes) unaccounted for, which might be fat or water.[1]

Third Period, Five Days after the Walk.—The record of the fifth day of the second period shows that the system had already begun to recuperate after the depression of the fourth day, notwithstanding the walk of forty and a half miles. The explanation of this is to be found in the long sleep and the amount of nitrogenized food taken. During the third period, the exercise was practically nothing, being only 2.2 miles daily; the sleep averaged 8 hours and 29 minutes; and the nitrogen of the food averaged 440.93 grains (28.569 grammes). Mr. Weston did nothing but eat, sleep, and amuse himself, and this was a period of complete bodily and mental repose, admirably calculated for recuperation after the immense muscular exertion of the five days before. At the end of the five days, the weight had advanced to 120.75 lbs. (54 k. 765 grammes); 0.25 of a pound (110.00 grammes) over the weight at the beginning of the observations. Immediately after the walk, Mr. Weston felt perfectly well and continued well for the five days, with the exception of a slight headache on the afternoon and evening of the fifth day. He smoked from five to seven cigars daily, but took no alcoholic stimulants. His diet was normal in variety, but on some days the quantity of solid food was very large.

On the first day, the nitrogen of the food was 385.65 grains (24.987 grammes), about 64 per cent. above the average for

[1] See the section on variations in weight.

the five days of the walk. The nitrogen of the urea and fæces amounted to 295.70 grains (19.159 grammes), about 18 per cent. below the average for the five days of the walk. This reduction in the amount of nitrogen excreted is very significant. For every 100 parts of nitrogen of food, there were discharged in the urea and fæces, 76.68 parts.

On the second day, the nitrogen of the food was very much increased, amounting to 499.10 grains (32.338 grammes). The nitrogen of the urea and fæces was 358.81 grains (23.248 grammes). For every 100 parts of nitrogen of food, there were discharged, 71.81 parts.

On the third day, the nitrogen of the food was diminished, though it still largely exceeded the standard for an ordinary man. On this day it was 394.83 grains (25.582 grammes). The nitrogen of the urea and fæces was largely increased, amounting to 409.87 grains (26.556 grammes). For every 100 parts of nitrogen of food, there were discharged, 103.81 parts. This excess of nitrogen discharged is to be attributed to the immense quantity of nitrogen taken with the food on the day before.

On the fourth day, the nitrogen of the food was in enormous quantity, amounting to 641.71 grains (41.578 grammes), more than double the average for an ordinary man. The nitrogen discharged in the urea and fæces was 382.89 grains (24.808 grammes). For every 100 parts of nitrogen of food, there were discharged, 59.67 parts. This proportion was reduced by the very large quantity of nitrogen taken with the food.

On the fifth day, the nitrogen of the food was reduced to a little below the average for an ordinary man, amounting to 283.35 grains (18.359 grammes). The nitrogen of the urea and fæces was 418.49 grains (27.125 grammes), much more than the discharge on any day during the fifteen. For every 100 parts of nitrogen of food, there were discharged, 147.69 parts. This active discharge of nitrogen is explained by the immense amount taken in the food on the previous day. On this day, at midnight, the observations were terminated.

The daily observations during this period, taken in connection with those during the five days before the walk, have established the following important fact with relation to the influence of nitrogenized food upon the excretion of nitrogen:

Every day that an excess of nitrogenized food was taken, it was followed, on the succeeding day, and, on one occasion, on the succeeding two days, by a largely increased discharge of nitrogen in the urea and fæces, the discharge on these days exceeding the amount taken in the food; but the general average for five days, during the period of five days before the walk, and the period of five days after the walk, was from 92 to 95 parts of nitrogen discharged, for every 100 parts of nitrogen introduced.

The average for the five days after the walk shows an introduction of 440.93 grains (28.569 grammes) of nitrogen daily, an excess of about 42 per cent. over the average for an ordinary man. For every 100 parts of nitrogen in the food, the average daily excretion, during this period, was 91.93 parts.

Influence of Exercise upon the Elimination of Uric Acid.

The results of the observations during the three periods, as regards the influence of the exercise during the five days of the walk, and the influence of food during the five days before and the five days after the walk, are unsatisfactory, and interesting chiefly in a negative point of view.

The quantities of uric acid for each day present very wide variations. For example, on the fourth day of the walk, the exercise being fifty-seven miles, the quantity was 9.21 grains (0.597 of a gramme), the greatest amount for any one day; and on the second day of the walk, the exercise being forty-eight miles, the uric acid was 0.14 of a grain (0.009 of a gramme); the smallest amount for any one day. On the second day of the first period, the quantity was 4.03 grains (0.261 of a gramme); and on the third day after the walk, the quantity was 0.31 of a grain (0.02 of a gramme). I have carefully compared the quantities for each day with the amount of exercise, and can find no definite relation between them. I have carefully compared the quantities for each day with the character and quantity of food, and with no more satisfactory result. Inasmuch as on certain days during the walk, Mr. Weston took immense quantities of coffee, it occurred to me that this might influence the uric acid; but I did not find any confirmation of this idea in the tables. I calculated also for each day the proportion of uric acid per 100 parts of urea discharged, with the view of confirming or disproving the idea that uric acid is really urea in an imperfect condition of oxidation; but the results of these calculations were also unsatisfactory. Finally, I compared the sleep and the meteorological record with the uric acid, and could establish no relation between them. The variations were so irregular that it was impossible to trace any influence upon the uric acid due to food or exercise, even if it be assumed that the influence might be protracted for a period of one or more days.

As it is impossible to draw any positive conclusions from a comparison of the quantities of uric acid excreted day by day, I can only refer to the averages for the three periods of five days each.

The average daily excretion of uric acid for the five days before the walk was 2.26 grains (0.127 of a gramme). The proportion of uric acid per 100 parts of urea for this period was 0.362 of a part.

The average daily excretion for the five days, walking in all 317½ miles, was 3 grains (0.194 of a gramme). The proportion of uric acid per 100 parts of urea for this period was 0.409 of a part.

The average daily excretion for the five days after the walk was 1.42 grains (0.082 of a gramme). The proportion of uric acid per 100 parts of urea for this period was 0.187 of a part.

These results, in view of the inexplicable daily variations in the uric acid, are not sufficiently definite to lead to any positive conclusions. As far as they go, they show an increase in the uric acid of about 33 per cent. during the period of extraordinary muscular exertion. During the period of complete muscular inactivity, with an excess of food, the excretion was diminished about one-half.

The observations have developed, however, the following negative facts:

1. There is no apparent relation between the increase of urea and of uric acid, except that both are increased, with the other solid constituents of the urine. In other words, in increasing the

urea by exercise, there is no evidence that the uric acid is oxidized and converted into urea; for if that were the case, with the increase in the quantity of urea, there would be a diminution in the proportion of uric acid per 100 parts of urea; and this does not occur.

2. It is not shown that the quantity of nitrogenized food has any influence upon the elimination of uric acid; unless it be assumed that the diminution in the uric acid, during the period of inactivity and excess of nitrogenized food, be due to the food alone.

The important physiological results which I hoped to arrive at by studying the uric acid, with the inevitable applications of such results to pathological conditions, were not realized; and it must be admitted that our positive knowledge of the relations of uric acid to nutrition and disassimilation has not been advanced by these researches, though some important negative facts have been developed.

Influence of Exercise upon the Elimination of Inorganic Salts by the Kidneys.

In studying the variations in the proportions of the inorganic salts in the urine, it will be seen that the phosphoric and the sulphuric acid are generally in about the same ratio to each other, their excretion being apparently increased and diminished by the same causes. With the chloride of sodium, however, it is different. For example, on the third day of the walk, the amount of phosphoric acid is very large, while the chloride of sodium is in very small quantity, nearly at the minimum. As it is not improbable that different causes may influence, on the one hand, the phosphoric and the sulphuric acid, and on the other, the chloride of sodium, it will be proper to consider the chloride by itself.

Phosphoric and Sulphuric Acid.—It is undoubtedly true that the excretion of the phosphates and sulphates by the kidneys is largely influenced by the quantity of these principles in the food. They must, however, pass into the urine in one or both of two ways; either directly from the blood, as the salts are taken up by absorption, without becoming a part of the tissues, or they may come from the tissues, by a process analogous to that of the production of urea. If these salts passed directly from the blood, their elimination would be almost entirely under the influence of the food, and this influence would be manifested soon after their introduction. If the phosphates and sulphates of the urine be derived from the tissues, in the process of disassimilation, when this process is increased in activity, as it was during the five days of the walk, the influence of the food would probably be overshadowed by the exaggerated activity of disassimilation, due to the extraordinary muscular effort. It is not possible to subject these questions to rigidly scientific inquiry without estimating exactly the phosphoric and the sulphuric acid in the food. This was impracticable; but the solid food was so little changed in its character during the different days of the three periods, that the variations in its quantity will be, to a certain extent, a measure of the introduction of the inorganic salts.

First Period, Five Days before the Walk.—During this period, the range of variation from day to day was from 43.01 to 67.00 for the phosphoric acid, and from 38.18 to 51.50 for the sulphuric acid. With one exception, these two acids varied from day to day in about the same ratio. On the first day, the phosphoric acid was in large quantity, with a small quantity of sulphuric acid. With the exception of the fifth day, both the phosphoric and the sulphuric acid were varied in a tolerably constant ratio to the variations in the nitrogenized food, being increased with the food, and *vice versa*. On the fifth day, when the quantity of nitrogenized food was the greatest, both the phosphoric and the sulphuric acid were below the average for the five days. On this day, the exercise was very slight, only one mile.

The most marked and constant variations during this period were with the exercise, especially in the phosphoric acid. On the first day, the exercise was fifteen miles; the phosphoric acid was 51.46 grains (3.334 grammes), the average for the five days being 50.14 grains (3.262 grammes), and the sulphuric acid was 38.37 grains (2.486 grammes), the average being 41.57 grains (2.693 grammes). On the fourth day, the exercise was fifteen miles; the phosphoric acid was 67 grains (4.341 grammes), and the sulphuric acid, 51.50 grains (3.337 grammes). On this day, the loss of weight was 24 oz. (687 grammes), the greatest amount of loss for any one of the five days. On the second and the third day, both the phosphoric and the sulphuric acid were slightly below the average for the five days, with five miles of exercise during each day. On the fifth day, with ten hours of sleep and one mile of exercise, the phosphoric acid was 43.01 grains (2.787 grammes), and the sulphuric acid, 38.18 grains (2.474 grammes), the smallest quantities during the five days.

During this period, the increase in the phosphoric and the sulphuric acid with the exercise was constant.

Second Period, Five Days of the Walk.—During this period, the ratio of variations between the phosphoric and the sulphuric acid was constant, with the exception of the fifth day, when the quantity of sulphuric acid was a little greater than on the fourth day, while the phosphoric acid was less. During this period, there was no definite relation between the quantities of these two acids and the nitrogenized food; the influence of the food being apparently overshadowed by the exercise. The relations between the phosphoric acid and the exercise were nearly absolute. Taking the exercise from the highest to the lowest points, the relations were as follows:

Third day.	Exercise	92 miles.	PO_5	102.25	grains	(6.625	grammes).
First day.	"	80 "	"	84.95	"	(5.504	").
Fourth day.	"	57 "	"	66.90	"	(4.296	").
Second day.	"	48 "	"	72.14	"	(4.674	").
Fifth day.	"	40½ "	"	57.49	"	(3.725	").

The variations in the sulphuric acid were not so absolute:

Third day.	Exercise	92 miles.	SO_3	63.71	grains	(4.128	grammes).
First day.	"	80 "	"	73.39	"	(4.755	").
Fourth day.	"	57 "	"	32.66	"	(2.116	").
Second day.	"	48 "	"	56.90	"	(3.687	").
Fifth day.	"	40½ "	"	40.84	"	(2.646	").

These calculations show a decided and nearly absolute relation between the excretion of phosphoric acid and the amount of exercise. On the fourth day, with fifty-seven miles of exercise, the nitrogen of the food was about forty-six per cent. less than on the second day, with forty-eight miles of exercise. This will, perhaps, account for the diminished excretion during the day of less exercise.

As regards the sulphuric acid, the conclusions are about the same as for the phosphoric acid. The diminished excretion on the second day is also accounted for by the small amount of nitrogenized food taken on that day.

Third Period, Five Days after the Walk.—During this period, the exercise was practically nothing; and this element does not, therefore, enter into the calculation of the variations of the inorganic constituents of the urine. Although the variations in the phosphoric and the sulphuric acid were considerable, as were the daily variations in the nitrogenized food, there seemed to be no definite relation between them. I shall, therefore, give for this period simply the extremes and the averages.

On the third day, the quantities both of phosphoric and of sulphuric acid were the greatest. The phosphoric acid was 105.68 grains (6.847 grammes). The sulphuric acid was 53.57 grains (3.471 grammes). On the first day, the phosphoric acid was least in quantity, being 29.06 grains (1.833 grammes), with 49.53 grains (3.209 grammes) of sulphuric acid. On the second day, the sulphuric acid was least in quantity, being 46.07 grains (2.985 grammes), with 46.93 grains (3.041 grammes) of phosphoric acid.

The averages for the five days of this period were as follows: Phosphoric acid, 56.89 grains (3.674 grammes); sulphuric acid, 49.02 grains (3.176 grammes).

Averages for the Three Periods.—The averages for the three periods of five days, each show very clearly the influence of exercise upon the elimination of phosphoric and sulphuric acid; and the averages for the period of five days before the walk, and the period of five days after the walk, show the influence of food, probably attributable to the phosphates and sulphates combined with the nitrogenized matters.

For the first period, five days before the walk, the average discharge of phosphoric acid was 50.14 grains (3.262 grammes), and of sulphuric acid, 41.57 grains (2.693 grammes). The average quantity of nitrogen in the food was 339.46 grains (21.994 grammes).

For the second period, five days of the walk, the average discharge of phosphoric acid was 76.63 grains (4.965 grammes), and of sulphuric acid, 53.50 grains (3.666 grammes). The average quantity of nitrogen in the food was 234.76 grains (13.211 grammes).

For the third period, five days after the walk, the average discharge of phosphoric acid was 56.89 grains (3.674 grammes), and of sulphuric acid, 49.02 grains (3.176 grammes). The average quantity of nitrogen in the food was 440.93 grains (28.569 grammes).

These averages show that the walk of 317½ miles in five consecutive days increased the excretion of phosphoric acid more than 50 per cent. over the excretion under ordinary conditions, notwithstanding that the nitrogenized food was diminished 31 per cent. Under the same conditions, there was an increase of about 30 per cent. in the excretion of sulphuric acid. The influence of exercise upon the excretion of the phosphates and sulphates, irrespective of the composition of the food, cannot be doubted.

A comparison of the averages for the first period, five days before the walk, and the third period, five days after the walk, shows an increase in the excretion of phosphoric acid, for the third period, of 13.4 per cent., with an increase of 30 per cent. in the quantity of nitrogenized food. Under the same conditions, the excretion of sulphuric acid was increased 19.2 per cent.

Chloride of Sodium.—In the absence of exact estimates of the quantities of chloride of sodium contained in the food of each day, there is little to be learned from the variations in excretion of this salt by the kidneys. Such estimates were manifestly impracticable. The salt used as a condiment was averaged for the four days of the first period, and for the fifth day of this period with the five days of the walk. For the five days after the walk, the quantity of salt used was weighed each day. I can form no definite idea of the salt used in cooking for the five days before the walk and the five days after the walk; but on some of the days of the walk, particularly the third and fourth, the diet consisted largely of beef-essence and oatmeal-gruel. No salt was added to the beef-essence, which was prepared under my own direction, and very little was used in the preparation of the oatmeal-gruel.

First Period, Five Days before the Walk.—The average quantity of salt used as a condiment during this period was 34.5 grains (2.235 grammes). During the five days, the proportion of nitrogenized food and the elimination of chloride of sodium presented no definite relation to each other. The variations in the chloride of sodium of the urine were not very considerable, and had no definite relation to the exercise. The greatest quantity was on the first day, amounting to 195.02 grains (12.636 grammes); and the smallest quantity was on the fourth day, when it was 106.68 grains (6.912 grammes). In the absence of any definite relation between the excretion of chloride of sodium and either the food or the exercise, I can only use the average for this period, which was 159.45 grains (10.331 grammes).

Second Period, Five Days of the Walk.—There are one or two interesting points in connection with the elimination of chloride of sodium during this period. The nitrogenized food, which would contain nearly all the chloride of sodium, was diminished 31 per cent., and the average quantity of salt used as a condiment was 35 grains (2.265 grammes). The average elimination of chloride of sodium by the kidneys was only 65.08 grains (4.217 grammes); but a large amount must have been eliminated by the skin, the average cutaneous and pulmonary exhalation daily being 138.41 oz. (3,875.18 grammes), against 61.63oz. (1,690.91 grammes), for the five days before the walk, and 62.82 oz. (1,706.78 grammes), for the five days after the walk.

On the third day, when the food contained, probably, the minimum proportion of salt, the salt of the urine was reduced to 44.45 grains (2.88 grammes), about 32 per cent. below the average for the five days. On the fourth day, it is probable that a little more salt was taken with the food. On this day, the exercise was fifty-seven miles; but it was on this day that Mr. Weston broke down, and was forced to take a long rest. The chloride of sodium for this day was reduced to 28.78 grains (1.865 gramme), nearly 56 per cent. below the average. On the next day, when reaction took place, the salt returned to about the average. In view of the disappearance of the chloride of sodium of the urine in certain febrile conditions, this diminution in its quantity on the day of great constitutional depression is interesting, though its exact significance is not apparent.

Third Period, Five Days after the Walk.—The variations in the chloride of sodium of the urine during this period were enormous. The smallest quantity was on the first day, when it was 66.41 grains (4.303 grammes). The largest quantity was on the third day, when it was 622.58 grains (40.338 grammes). The quantity of urine on this day was 84.18 fl ℥ . (2,490 c. c.). I could not connect these variations with the diet, or with the salt used as a condiment, which was weighed each day, and varied considerably. The only point connected with the daily variations during this period is the excessively small quantity on the day next after the walk, when it was only 66.41 grains (4.303 grammes), while the salt actually used as a condiment on that day was 65.62 grains (4.252 grammes).

The average daily quantity of chloride of sodium of the urine for this period was 312.40 grains (20.241 grammes). The nitrogenized food was increased 30 per cent. over the average for the five days before the walk. The average quantity of salt used as a condiment was 42 grains (2.721 grammes), an increase of nearly 22 per cent. over the average for the five days before the walk.

Averages for the Three Periods.—The averages for the three periods of five days each are as follows:

First period, five days before the walk, 159.45 grains (10.331 grammes).

Second period, five days of the walk, 65.08 grains (4.217 grammes).

Third period, five days after the walk, 312.40 grains (20.241 grammes).

These averages show a great diminution in the chloride of sodium of the urine during the walk, due in a great measure, undoubtedly, to a diminution in the quantity of salt ingested. In the absence of exact estimates of the quantity of salt introduced, it is impossible to state definitely the influence of exercise on its elimination by the kidneys. Probably it is diminished, a much larger amount than usual being eliminated by the skin. An argument in favor of this view is the small quantity in the urine the day next after the walk, when a large quantity was introduced with the food.

The only explanation I can offer of the great increase in the chloride of sodium during the five days after the walk is in the larger quantity taken with the food, and, possibly, the cessation of the influences which diminished it in the urine during the five days of the walk.

Abnormal Matters in the Urine.

There is very little to be said with regard to the abnormal matters discovered by microscopical examination of the urinary sediments. During the first period, five days before the walk, there was a constant deposit of octahedra of the oxalate of lime. During the second period, five days of the walk, the oxalate was found daily. On the fifth day of this period, in addition to the oxalate, there was a small quantity of the amorphous phosphates. The oxalate continued during the third period, five days after the walk, with the exception of the fourth day, when there were no abnormal matters. On the first day of this period, the sediment contained, in addition to the oxalate, amorphous urates in small quantity. On the second and the third day of this period, in addition to the oxalate, the sediment contained crystals of uric acid. On these days, the amount of uric acid in the urine, as determined by analysis, was very slight, and the crystals were probably due to increased acidity of the urine. I can offer no explanation of the presence of any of these crystals in the urine, nor can I connect them with any of the conditions observed.

On the second and the third day of the third period, five days after the walk, the urine contained a trace of sugar. There was no increase in the amount of starchy and saccharine principles in the food on these days to account for the sugar, the presence of which cannot be readily explained.

In conclusion, it is evident, from the results of these investigations, that the great question of the influence of muscular exercise upon the elimination of nitrogen can be accurately studied only by comparing the nitrogen of the food with that of the excretions; and this should be done, if possible, upon a perfectly physiological diet. It is indispensable, also, to extend the experiments over periods of several days each; otherwise the results will necessarily be confused and unsatisfactory. The observations with regard to the weight and various other conditions were necessary to control the more important points to be considered. The great amount of material collected and its analysis and tabulation have involved considerable labor, which, however, has been rewarded by important conclusions of a definite and positive character.

At the risk of presenting to the reader an unattractive mass of statistics, I have felt it my duty to publish, not only the general facts and deductions, but the exact data collected, arranged in a form that may be useful to other investigators. I feel confident that I will not be reproached for tediousness of detail by those who are interested in the important physiological questions involved, particularly those who have carefully studied the literature of these questions for the past few years.