XXVII. *Experiments on Respiration.*—Second Communication. *On the Action of Foods upon the Respiration during the primary processes of digestion.* *By* EDWARD SMITH, *M.D., LL.B. (Lond.), M.R.C.P., Corresponding Member of the Académie des Sciences et Lettres de Montpellier, and of the Natural History Society of Montreal, Assistant-Physician to the Hospital for Consumption, Brompton, &c. Communicated by Sir* B. C. BRODIE, *Bart., P.R.S.*

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IN a paper which I have recently had the honour to forward to the Royal Society, I showed that there are alternate elevations and depressions of all the respiratory phenomena during the day, due to the temporary influence of food, and that the maximum influence of food always occurs in from $1\frac{1}{2}$ to $2\frac{1}{2}$ hours after the meal. I also proved, from the state of the system in a prolonged fast, as well as from the tolerably uniform state at the end of the interval between the meals, that there is on each day a basal or normal line below which the amount of respiratory action does not ordinarily fall; and I also showed that there is a maximum elevation from food which is tolerably uniform, and which is the most pronounced after the breakfast and tea meals. Hence it appeared that the influence of food is in two degrees:—1st, that which lies between those two lines and exceeds the normal or basal line; and 2nd, that which sustains the system up to the minimum or basal line. The former action is temporary and of short duration, whilst the latter is permanent.

Proceeding from these facts, I have prosecuted a lengthened inquiry into the influence of numerous articles of food over the respiration, when taken separately and not in the combined form in which we take them at meals, and have endeavoured to ascertain what is their maximum effect. As nearly all food tends to sustain and increase the vital actions, and as in the total absence of food for a lengthened period the respiratory changes are sustained to the extent of 75 per cent. of that with food, my inquiries have been almost entirely directed to determine that influence, which acts so as to appear between the maximum and minimum lines just mentioned. Except within very narrow limits, I have not found any substance taken as food or with food which materially lowers that minimum line; and, moreover, I do not know any method whereby it would be possible, in a state of health, to show the action of any substance which acts much below it. Hence my aim has been to show to what extent various substances raise the respiratory changes above or depress them below a basal line, and not merely to state what absolute amount of carbonic acid, for example, was evolved during their action. The former could be referred to no other cause than the food under experiment;

but since, as has been just mentioned, so great a part of the latter would have occurred if the food had been withheld, it is impossible to affirm that it was due to its influence. This has afforded me an inquiry of a well-defined nature, and one which my apparatus permitted me to make with ease; and it is one, moreover, so far as I know, not heretofore pursued.

Nearly all previous inquiries have been made upon the lower animals, and have had for their object to determine the effect upon nutrition of the exclusive use or the entire absence of certain substances, and only a few experiments have been made upon Man. PROUT* ascertained that the per-centage of carbonic acid in the expired air was somewhat lessened under the influence of both tea and alcoholic liquors; and VIERORDT† found the same result from the latter *without any appreciable difference in the other phenomena of respiration.* BOEKER‡ has made the most remarkable inquiries into this subject; and the method adopted by him was to take a considerable quantity of the substance, as sugar, for example, at several periods of the day, in addition to his ordinary food, and afterwards ascertain the state of the excretions and the respiration at several irregular periods. When we recollect how great is the variation in the quantity of carbonic acid evolved at different periods of the same day, and how irregular is the quantity on different days,—how powerful is the effect of exertion, an influence which cannot under ordinary circumstances be the same on any two days,—the disturbing influence of unusually large or often repeated quantities of a substance, and lastly, the unknown influence of other articles of food, varying in quantity and quality,—it is easy to see how difficult it would be for M. BOEKER to eliminate the normal and true effect of the article under inquiry. He found that sugar, coffee, and alcohol lessened the respiratory changes, and that in their principles of action they are identical; but he then inquires how it is, if this be so, that they act as antidotes to each other? It will be shown that my results do not accord with his. Mr. MILNER§, Surgeon to the Government Prison at Wakefield, in a paper which he recently read before the British Association, states that he had proved by experiment that tea given to the prisoners, whether in lieu of, or in addition to their ordinary food, caused them to lose weight at an increasing rate,—a fact which supports my results on the action of that substance.

My experiments have been made chiefly upon myself, æt. 39, and upon Mr. MOUL, æt. 48 (a gentleman whose devotion to the inquiry in the interests of science is beyond all praise), but in a few instances upon others also. The plan pursued was as follows:—

A quantity of the substance under inquiry, not greatly different from that ordinarily taken by mankind, was administered apart from any other food. The experiments were nearly all made from 7 to 9 A.M., before breakfast; but some were made at 2 P.M., after the influence of the breakfast had passed over. All were made in the sitting posture, and in the absence of all exertion and mental and bodily excitement. Hence we isolated the influence of the substance, and made one long series of experiments under precisely

* THOMSON'S 'Annals of Philosophy.'

† Physiologie des Athmens.

‡ Beiträge zur Heilkunde, &c., 1849.

§ Sanitary Review, 1858.

similar and normal conditions. We sat down at least a quarter of an hour before taking the first observation, or that which showed the state of the system before the substance under inquiry was taken, and which was the basal state with which the subsequent effects of the substance were compared, and upon the accuracy of which the truthfulness of the results mainly depended. We then ate the substance in question, and in from 3 to 10 minutes afterwards made our first inquiry into its effects; and repeated the inquiry every 12 or 15 minutes (as frequently as we could complete each experiment), until the maximum effect had passed; the same conditions as to posture and quietude being maintained unbroken throughout the whole inquiry. We did not continue the experiment beyond our usual breakfast hour; for, in accordance with a statement made in my former paper, we found that an increase in the respiratory phenomena occurred at the meal hour before any food had been taken. Hence it was neither necessary nor desirable to continue the inquiry much beyond two hours. Each of these experiments lasted five minutes, but in several of them the inquiry was continuous, and the whole of the carbonic acid evolved during the action of the substance was collected.

In recording the results, we made use of the total quantities; but in abstracting them for the purposes of this communication, I have compared them with the basis quantity, and have given the amount of increase or decrease only. This was necessary, both on account of the observation made above, and because the total quantities varied with the season.

The apparatus employed was that described in my previous paper*, consisting of an instrument to measure the quantity of inspired air, and an analytical apparatus to abstract the vapour and carbonic acid from the whole of the expired air. The force of inspiration and expiration was in a few instances determined by a bent tube with a column of water attached to the mask; and the temperature of the expired air was determined by the aid of a small thermometer inserted at right angles into a box-wood tube, $1\frac{1}{2}$ inch in length, and protected by valves, as described in my paper published in the 'Proceedings' of the Society for 1857. The temperature with the wet and dry bulb, and the barometric pressure, were recorded, as was also the state of the weather.

The foods which have been the subjects of inquiry are very numerous, and of the finest quality; and some of them, as tea, sugar, milk, and alcohols, were subjected to very numerous and varied experiments. As the results have shown that it would be inconvenient to arrange them solely according to their chemical constitution, I purpose to describe them under the following heads:—

1. *The Starch Series*, viz. arrowroot, arrowroot and butter, arrowroot and sugar, commercial starch, wheat starch, gluten, bread, oatmeal, rice, rice and butter, potato, gum.
2. *The Fat Series*, viz. butter, olive oil, cod-liver oil.
3. *Sugars*, viz. cane-sugar, cane-sugar and butter, cane-sugar with acids and alkalies, grape-sugar, milk-sugar.

* Page 682 of this volume.

4. *The Milk Series*, viz. new (cows') milk, skimmed milk, casein, casein and lactic acid, lactic acid, sugar of milk and lactic acid, cream.
5. *Alcohols*, viz. spirits of wine, brandy, whisky, gin, rum, sherry and port wine, stout, ale.
6. *The Tea Series*, viz. tea, green and black, hot and cold, in different quantities, and with acids and alkalies; coffee, coffee leaves, chicory, cocoa.
7. *Certain other nitrogenous substances*, viz. gelatin, albumen, fibrine, almond-emulsion*.

The immediate object of inquiry was the effect of these various substances over the carbonic acid and vapour exhaled, the quantity of air inhaled, and the rate of pulsation and respiration. The inquiry as to the amount of vapour exhaled was chiefly pursued in the experiments on alcohols.

I shall describe the effect of these various substances in the order now given, and in order to avoid repetition shall reserve some general observations until the end of the paper. The whole of the detailed results, forming many sheets of tables accompanying this paper, are delineated on Plates XXXV. and XXXVI.

1. *The Starch Series.*

The general expression of the results obtained, is that starch does not excite the evolution of carbonic acid, whilst the ordinary foods, containing starch with other substances, as sugar and gluten, are powerful and enduring respiratory excitants.

Arrowroot.—June 19 (7 experiments†). The purest starch which I could obtain was arrowroot. The effect of 500 grs., well cooked with water, was an average increase of only ·154 gr. of carbonic acid per minute in myself, and ·208 gr. in Mr. Moul (Plate XXXV. fig. 3). On another occasion, September 6 (6 exps.), 750 grs. gave me an average decrease of ·08 gr. per minute. In the first inquiry there was an average decrease in the air inspired of 8 cubic inches per minute in myself, and an increase of 10 cubic inches in Mr. Moul, whilst in the last I had an increase of 5 cubic inches per minute. The rate of respiration was reduced in all the inquiries, whilst that of pulsation was decreased in Mr. Moul 3 per minute in the first, and increased in myself 3 per minute in the last.

When taken after a long fast, as described in my former paper, page 696, 500 grs. gave a maximum increase of ·45 gr. of carbonic acid per minute.

Starch, &c.—June 14 (10 exps.). Starch, imperfectly washed from 4 oz. of wheat flour, and therefore associated with other substances, gave a maximum increase of 2·1 grs. of carbonic acid per minute in myself, and 44 cubic inches of air inspired. There was a decrease in the rate of respiration, and a very slight increase in the rate of pulsation. When the starch had been much better washed, June 24 (7 exps.), Plate XXXV. fig. 6, the increase in the carbonic acid was ·52 gr., and 14 cubic inches of air inspired.

* It will be borne in mind that in this series of inquiries the amount of hydrogen consumed was not determined.

† This expression means that 7 observations were made upon each of us (or 14 on both of us) at regular intervals during the continuance of this experiment.

Bread.—April 13 (6 exps.), Plate XXXV. fig. 7. 4 oz. of white home-made bread gave maxima of increase in the carbonic acid of 1·48 gr. and 2·4 grs. per minute to myself and Mr. MOUL respectively, and on another occasion, April 23 (7 exps.), of 1 gr. and 2·2 grs. respectively. The quantity of air was increased on the two occasions 60 cubic inches and 20 cubic inches per minute in myself, and 96 cubic inches and 118 cubic inches per minute in Mr. MOUL. The rate of respiration was not increased in myself or in Mr. MOUL, and in the latter the pulsation fell somewhat. The effect was very enduring.

Oatmeal.—April 26 (7 exps.), Plate XXXV. fig. 10, July 9 (8 exps.), fig. 11. 4 oz. of good Scotch oatmeal, made into pudding with water, gave me a maximum increase of carbonic acid, on two occasions, of 1·63 gr. and ·93 gr. per minute, and to Mr. MOUL of 1·32 gr. per minute. The volume of air inspired by myself was increased 55 cubic inches and 19 cubic inches, but Mr. MOUL had a less increase. The respirations were lessened, and the pulsations were not increased. The effect was very enduring.

Rice.—April 28 (8 exps.), May 13 (8 exps.), Plate XXXV. fig. 9. 4 oz. of the best rice, well cooked, gave me maxima of increase in the carbonic acid of 1·9 gr. and 1·44 gr. per minute, and Mr. MOUL of 1·15 gr. and 1·94 gr. per minute. I had a maximum increase in the volume of air of 54 cubic inches and 40 cubic inches per minute, and Mr. MOUL of 44 cubic inches and 96 cubic inches per minute. There was generally a diminution in the rate of respiration, and an increase in that of pulsation. The effect was very enduring.

Potato.—May 17 (8 exps.), Plate XXXV. fig. 12, July 21 (6 exps.), fig. 13. 8 oz. of very good cooked potato, with 3 oz. of cold water, gave a maximum increase of carbonic acid in myself of 1·27 gr., on two occasions, and 52 cubic inches and 20 cubic inches in the air inspired. The rate of respiration was in both instances reduced, as was also that of pulsation, but in a less degree. The potatoes were old in the first and new in the second inquiry.

Commercial Starch.—June 18 (6 exps.). 500 grs. of commercial starch gave me a maximum increase in carbonic acid of ·8 gr. per minute, and of air 22 cubic inches per minute, whilst the rate of both respiration and pulsation was slightly increased.

Gluten.—June 11 (8 exps.), June 16 (8 exps.), Plate XXXV. fig. 8. The gluten washed out of 4 oz. of fine wheat flour gave me a maximum increase in carbonic acid of ·84 and ·74 gr. per minute, and in air of 8 cubic inches and 11 cubic inches per minute. The rate of respiration was decreased very slightly, whilst that of pulsation was increased on one occasion and decreased on another.

Arrowroot and Butter.—June 21 (6 exps.), Plate XXXV. fig. 4. 1 oz. of fresh butter, added to 500 grs. of arrowroot, gave me an average increase in carbonic acid of ·17 gr. per minute, and a maximum increase of ·4 gr. per minute. The quantity of air inspired was somewhat lessened, as was also the rate of respiration. The pulsation was increased 4 per minute.

Rice and Butter.—May 14 (8 exps.). 1 oz. of butter, with 4 oz. of rice, gave to myself

and Mr. MOUL an average increase of ·84 gr. and 1·25 gr. of carbonic acid, and a maximum increase of ·94 gr. and 1·9 gr. per minute respectively. The quantity of air was increased 14 cubic inches and 22 cubic inches. The rate of respiration was reduced, and to the extent of 2·6 per minute, whilst that of pulsation was increased 9 and 6 per minute.

Arrowroot and Sugar.—September 13 (7 exps.), Plate XXXV. fig. 5. 250 grs. of sugar, added to 500 grs. of arrowroot, gave a maximum increase of 1 gr. of carbonic acid, and 20 cubic inches of air per minute in forty minutes. The rate of respiration was progressively reduced, whilst that of pulsation was temporarily increased.

Hence it appears—

1. That pure starch exerts but an insignificant influence over the increase of carbonic acid and over pulsation, and that after a fast of twenty-four hours the influence is but very slightly increased.

2. That wheat flour, oatmeal, and rice have a great and very similar influence over respiration, both in degree and duration; but the latter differs from the others in increasing the rate of pulsation. In each of them there remained an increase of 1 gr. of carbonic acid per minute after the lapse of two hours.

3. That potato differs from the foregoing less in the amount of its maximum influence than in the shorter duration of its influence, the subsidence from the maximum being very rapid. New and old potatoes had the same influence.

4. The foregoing invariably reduced the rate, and thereby increased the depth of respiration.

5. The proportion of carbonic acid to the inspired air was increased by these substances to the greatest extent in rice, and the least in potato. The maximum increase of air and carbonic acid almost invariably occurred together.

6. The maximum influence was obtained in from $1\frac{1}{2}$ to 2 hours, and it was the same in wheat, oatmeal, and rice, and nearly the same in potato.

7. The addition of fat to starchy foods did not increase, but rather lessened the influence of the latter. It however increased the influence over pulsation.

8. Gluten exerts a considerable influence, but much less than that of bread, oatmeal, and rice. Its effects were very uniform on two occasions. Its maximum influence was produced in forty minutes, and the whole effect ended in about two hours.

9. Arrowroot, alone, gave no sense of satisfaction (all our experiments were made whilst fasting), but, on the contrary, there was in about one hour an unnatural sensation of sinking in the stomach and small intestines.

With bread there was a sweet taste in 14 to 20 minutes; and with bread, rice, and potato sour eructations in 35 minutes. The inspirations were forcible.

2. *Fats.*

Fat, like starch, does not excite the respiration.

Butter.—June 25 (7 exps.), Plate XXXV. fig. 2. 500 grs. of butter gave me an

average increase of carbonic acid of only ·05 gr., and a maximum of ·34 gr. per minute. There was a maximum decrease of 33 cubic inches in the air inspired, and a progressive decrease in the rate of both respiration and pulsation. On another occasion, June 28 (7 exps.), there was an average decrease of ·11 gr. of carbonic acid per minute, with decrease in the rate of respiration and the quantity of air inspired.

Olive Oil.—February 22 (8 exps.). 1 oz. of olive oil gave me an average increase of ·11 gr. of carbonic acid, and a maximum of ·55 gr. per minute. The quantity of air was not materially varied, but there was a diminution in the rate of respiration.

Cod-liver Oil.—March 8 (6 exps.), Plate XXXV. fig. 1. 1 oz. of cod-liver oil gave me an average decrease of carbonic acid of ·27 gr., and a maximum decrease of 18 cubic inches of air per minute. The rate of respiration was decreased 1 per minute. On another occasion, June 24 (8 exps.), the average increase of carbonic acid was ·03 gr. per minute, with a maximum decrease of 19 cubic inches in the inspired air. There was also a diminution in the rate of respiration, and an increase in that of pulsation.

Hence—

1. The general tendency of these fats was to lessen the above-mentioned respiratory changes, but the variation, whether above or below the basis, was not great.

2. The rate of respiration was always lessened, whilst that of pulsation was usually increased. The quantity of air was lessened disproportionately to the carbonic acid, and thereby the proportion of the latter was increased.

3. Both cod-liver oil and butter produced a soothing effect, whilst with all the fats the respiratory efforts were feeble, and in about 20 to 30 minutes there was a slight sense of oppression at the heart.

I am of the class of persons who are fond of fat, whilst Mr. Moul dislikes it.

3. *Sugars.*

Sugar, unlike starch and fat, powerfully excites the respiratory changes. I have made a very extensive series of inquiries into its influence.

Cane-sugar.—April 14 (6 exps.), Plate XXXV. fig. 23; May 1 (7 exps.), fig. 22. The maximum increase in the carbonic acid, due to 1½ oz. of white sugar dissolved in water, was 2·18 grs. per minute in myself on two occasions, and 1·5 gr. and 2·71 grs. per minute in Mr. Moul. There was an increase of about 1 gr. per minute within 10 minutes, and the maximum increase was attained in about 25 minutes, after which there was a rapid subsidence. The whole effect did not usually pass away in less than two hours. The maximum increase in the air inspired was per minute 74 cubic inches and 111 cubic inches in myself, and 30 cubic inches and 100 cubic inches in Mr. Moul. The rate of respiration was lessened, and the depth was increased 8 cubic inches and 6·6 cubic inches in myself, 8 cubic inches and 12·2 cubic inches in Mr. Moul. The rate of pulsation was lessened.

August 25 (6 exps.).—The effect upon Mr. Reid, Surgeon to the Canterbury Hospital, who made an experiment for the first time, was a maximum increase of 1·9 gr. of car-

bonic acid in 25 minutes, and after the expiration of 70 minutes the increase was still 1·42 gr. per minute. The pulse was fuller and more frequent.

May 10 (13 exps.), Plate XXXV. fig. 25.—½ an oz. of sugar, taken at intervals of one hour, gave me a maximum increase of carbonic acid, on each occasion, of 1·3 gr., and of air of 26 cubic inches, 25 cubic inches, and 11 cubic inches per minute over the first basis quantity. The depth of inspiration was increased on each occasion, and the pulsation was somewhat decreased. On the second occasion the sugar was eaten dry; and as an uneasy sensation followed, water was drunk in one hour afterwards, and was followed by a renewed increase in the carbonic acid evolved.

On another occasion, May 18 (9 exps.), fig. 24, ½ an oz. of sugar, with 3 oz. of water, taken twice, with an interval of 1 hour, gave me a maximum increase in carbonic acid of 2·18 grs. per minute in 23 minutes in the first, and ·52 gr. per minute in 23½ minutes in the second experiment, whilst in Mr. Moul the increase was ·86 gr. and 2·14 grs. per minute in the same period. The maximum increase in the quantity of air inspired at the same period was 51 cubic inches and 29 cubic inches per minute in myself, and 58 cubic inches and 52 cubic inches per minute in Mr. Moul. The depth of inspiration was considerably increased in both persons.

May 21 (19 exps.).—500 grs. of white sugar, dissolved in 6 oz. of cold water, were taken, and the whole of the carbonic acid evolved afterwards was collected and weighed every half hour. In the first half hour the increase was 1·57 gr. per minute, and in the second half hour ·58 gr. per minute; whilst the quantity evolved at 95 minutes, when the inquiry ended, was ·12 gr. per minute above the basis quantity. The increase in the carbonic acid, in the first hour, was thus 57·5 grs. The quantity of air inspired was registered every 5 minutes. The maximum increase was 64 cubic inches in 35 minutes, and the quantity was reduced to the basis in 85 minutes. The average increase was 19·3 cubic inches per minute in the first half hour, 30·6 cubic inches per minute in the second half hour, and 8·3 cubic inches per minute in the third half hour. The rate of respiration was scarcely changed, and hence the depth of inspiration varied as the quantity of air inspired.

Cane-sugar and Vinegar.—June 29 (7 exps.), Plate XXXV. fig. 26. 750 grs. of white sugar, with 6 drachms of good vinegar and 7 oz. of water, gave a maximum increase per minute of carbonic acid of 3·3 grs. in 20 minutes. The average increase in 1½ hour was 1·24 gr. per minute; the maximum increase in the air inspired was 79 cubic inches in 20 minutes, and in the depth of inspiration 4·1 cubic inches. The rate of respiration was increased slightly, and that of pulsation 5 per minute.

October 4 (6 exps.).—The repetition of this experiment in October (but with raw sugar) gave a less increase, and at a later period.

June 24 (7 exps.).—With 30 grs. of citric acid instead of the vinegar, the maximum increase in carbonic acid in myself was 1·74 gr., and in Mr. Moul 2·25 grs. per minute. The increase of air inspired was 47 cubic inches and 20 cubic inches per minute.

July 5 (8 exps.), Plate XXXV. fig. 27.—750 grs. of white sugar, with 40 ♏ of

Liquor Potassæ in 12 oz. of water, gave me a maximum increase in carbonic acid of 2·13 grs. per minute, and after 100 minutes the increase was more than 1 gr. per minute. The maximum increase in the air inspired was 165 cubic inches per minute, in a little less than one hour. The rate of respiration was scarcely altered, but that of pulsation was lessened 7 per minute in $1\frac{1}{4}$ hour.

Cane-sugar and Butter.—July 1 (8 exps.), Plate XXXV. fig. 28. 750 grs. of white sugar, with 500 grs. of butter, and without water, gave a maximum increase of only 1·3 gr. of carbonic acid per minute, of air 48 cubic inches per minute, and in depth of inspiration 3·8 cubic inches. The pulsation was slightly increased.

Grape-sugar.—July 2 (7 exps.), Plate XXXV. fig. 29. 500 grs. of grape-sugar, dissolved in 10 oz. of hot water, gave a maximum increase in carbonic acid of 1·04 gr. per minute in 55 minutes; whilst on another occasion, July 8 (7 exps.), 750 grs. gave an increase of 1·1 gr. per minute in 50 minutes. The maximum increase in the quantity of air inspired per minute was 8 cubic inches and 23 cubic inches. The rate of respiration was lessened, as was also that of pulsation, in the first experiment.

Milk-sugar.—June 12 (7 exps.), Plate XXXV. fig. 20. 250 grs. of sugar of milk, with 6 oz. of hot water, produced a maximum increase in carbonic acid per minute of 1·62 gr. in myself, and ·66 gr. in Mr. Moul. The volume of air inspired was increased 24 cubic inches and 29 cubic inches per minute. The rate of pulsation fell, in Mr. Moul, 5 per minute, and that of respiration 1·5 per minute, whilst in myself the subsidence was to a less extent.

Hence it is proved—

1. That sugar in every form is a powerful respiratory excitant.

2. The action is almost immediate, and it rapidly rushes up to a maximum, but the whole effect does not disappear in less than from $1\frac{1}{2}$ to 2 hours.

3. When taken dry the effect is lessened, and the subsequent addition of water increases its action.

4. *In some conditions* the addition of an acid increased the degree, but lessened the duration, of its influence, whilst that of an alkali had the contrary effect. The variation in these results is in accordance with the variation which I have found in the action of acids and alkalies alone. The contrast in the experiments on June 29 and July 5 is very striking.

5. The addition of fat lessened its action.

6. Milk-sugar has less influence than cane-sugar, and grape-sugar has less influence than either.

7. The rate of respiration was always lessened, except when acid was added to the sugar, whilst that of pulsation was sometimes increased, and particularly with acid and fat; but when an alkali was added, it was decreased considerably.

The depth of inspiration was always largely increased.

8. There was a sense of great ease and depth in both inspiration and expiration. In 5 minutes there was sometimes a sour taste; and although there was commonly at first

a comfortable feeling, in 1½ hour there was usually craving for food,—a circumstance very different from that which occurs with ordinary *foods*.

The urine in one instance (May 10) had a celery odour.

9. With both sugar and starch, but especially with the former, there was a very unusual condensation of vapour in the mask.

10. The proportion of carbonic acid to the air inspired was always increased, but it was the most so with the sugar and potass, when the proportion of 1 gr. of carbonic acid to 52 cubic inches of air was increased to as 1 : 44 cubic inches at the period of maximum increase of the air and the carbonic acid.

I like sugar moderately, but Mr. MOUL dislikes it.

4. *The Milk Series.*

Milk, a highly complex body, both as a whole, and in nearly all its elements, excites the respiratory function.

New Milk.—April 3 (5 exps.), Plate XXXV. fig. 14, April 8 (5 exps.). One pint of cold good new cows' milk gave me a maximum increase of 2·26 grs. of carbonic acid per minute on one occasion, and 1·9 gr. per minute on another. With the latter, the maximum increase in Mr. MOUL was ·94 gr. per minute. The maximum increase in the inspired air was 96 cubic inches per minute in myself, and 22 cubic inches per minute in Mr. MOUL. The rate of both respiration and pulsation was increased in myself, but not in Mr. MOUL.

Skimmed Milk.—June 9 (5 exps.), Plate XXXV. fig. 15. One pint of good skimmed milk gave me a maximum increase of carbonic acid per minute of ·84 gr., and Mr. MOUL of ·54 gr. per minute. The volume of air was increased 21 cubic inches per minute in myself, but there was a decrease in Mr. MOUL. The rate of respiration was decreased 1 per minute in both, and that of pulsation 8 per minute in Mr. MOUL.

Casein.—June 10 (7 exps.), Plate XXXV. fig. 17, June 11 (7 exps.). The casein of 1 pint of good skimmed milk, well washed with water, gave me, on two occasions, a maximum increase in carbonic acid of 1·34 gr. and ·92 gr. per minute; but Mr. MOUL had a decrease, and the maxima of decrease were ·38 gr. and ·6 gr. per minute. My maximum increase in the volume of air inspired was 28 cubic inches in the first, but there was no increase in the second experiment, whilst in Mr. MOUL the maximum decrease was 26 cubic inches and 28 cubic inches per minute. My rate of respiration and pulsation was nearly unchanged, but Mr. MOUL had a decrease in both.

Lactic Acid.—June 7 (7 exps.), Plate XXXV. fig. 19. 40 ♏ of lactic acid in 8 oz. of water, gave me a maximum increase in carbonic acid of ·42 gr., and Mr. MOUL a maximum decrease of ·8 gr. per minute. There was a slight decrease in the quantity of air inspired, and a decrease in the rates of both respiration and pulsation, but the diminution in that of respiration was greatest in myself, and that of pulsation in Mr. MOUL.

Casein and Lactic Acid.—June 14 (8 exps.), Plate XXXV. fig. 18. The casein of 1 pint of skimmed milk and 40 ♏ of lactic acid with water, gave me a maximum

increase of ·91 gr. of carbonic acid and 19 cubic inches of air per minute. The rate of respiration slightly increased at first and decreased afterwards, and that of pulsation slightly increased.

Milk-sugar.—June 12 (7 exps.), Plate XXXV. fig. 20. I have already stated the effect of sugar of milk.

Milk-sugar and Lactic Acid.—June 15 (8 exps.), Plate XXXV. fig. 21. 250 grs. of sugar of milk and 40 ♏ of lactic acid, with 8 oz. of hot water, gave me a maximum increase in carbonic acid of 1·18 gr., and in air of 22 cubic inches per minute. The rate of respiration fell slightly, whilst that of pulsation was scarcely changed.

Cream.—June 22 (6 exps.), Plate XXXV. fig. 16. 2 oz. of good fresh cream produced in myself an average increase of ·24 gr., and a maximum increase of ·48 gr. of carbonic acid per minute; whilst in Mr. MOUL there was a maximum decrease of ·58 gr. per minute.

June 23 (8 exps.).—2½ oz. gave me an average increase of ·29 gr., and a maximum of ·64 gr. of carbonic acid per minute. The volume of air was increased in myself 33 cubic inches and 19 cubic inches per minute, but in Mr. MOUL it was lessened 42 cubic inches per minute. My rate of respiration was slightly increased in the first experiment, and Mr. MOUL's fell 1 per minute. My rate of pulsation was somewhat increased.

The effect of rum and milk will be described in the alcohol series.

These experiments show—

1. How different the effects of milk are upon different persons, and that there is a relation between this variation and the enjoyment of the food. I am fond of milk, but Mr. MOUL states that neither he nor any of his family can take cheese or milk. As the difference in reference to the influence of milk and its components is very striking, I have tabulated the results for their more ready appreciation.

Thus the increase or decrease of carbonic acid in grains per minute was—

	New milk.	Skimmed milk.	Casein.	Sugar of milk.	Cream.	Lactic acid.
	grs.	gr.	gr.	gr.	gr.	gr.
Myself	+ 2·26, 1·98	+0·84	+ 1·34, 0·72	+1·62	+ 0·48, 0·64	+0·42
Mr. Moul	+ 0·28, 0·94	+0·54	− 0·38, 0·6	+0·66	−0·58	−0·8

2. That there is no element in the milk (except the acid in some conditions) which is not excito-respiratory.

3. That no artificial combination of the component parts of milk produces the effect upon the respiration which follows the use of the natural combination.

4. That new milk has greater influence over the respiration than skimmed milk, and that the cream has greater influence than was found to exist in butter.

5. The rate of respiration and pulsation was increased by new milk and by cream in myself, whilst it was lessened by skimmed milk and lactic acid, and was unchanged by casein.

6. The proportion of carbonic acid to the inspired air was slightly increased.

5. *Alcohols.*

Alcohol, and substances containing much alcohol, disturb the respiration rather than influence it uniformly in any direction. Certain members of the class increase, whilst others decrease the activity of that function, probably according to the elements other than alcohol of which they are composed.

Alcohol.—March 9 (8 exps.). 11 drachms of Spt. Vini (76 per cent. of pure alcohol) in 6 oz. of cold water, caused in myself an average increase of ·18 gr. of carbonic acid, and a maximum of ·46 gr. per minute; and on another occasion, May 6 (7 exps., Plate XXXVI. fig. 44), an average increase of ·8 gr. and a maximum of 1·64 gr. per minute. Mr. MOUL on the latter occasion had no average change, but a maximum decrease of ·72 gr., and an increase of ·4 gr. per minute. The quantity of air was increased 47 cubic inches and 53 cubic inches per minute in myself, and 26 cubic inches per minute in Mr. MOUL. The rate of respiration declined throughout in the first, but in the second experiment there was an increase in both of us, and a subsequent decrease in myself.

Dec. 21 (5 exps.), fig. 45.—I took ½ an oz. of alcohol, spec. grav. ·858 (76 per cent.), with 2 oz. of cold water, every quarter of an hour for three times, after which (as also in the experiment on March 9) I was nearly unconscious. The carbonic acid was increased ·74 gr. per minute, and the air 37 cubic inches per minute. The rate of respiration was scarcely changed, but that of pulsation rose. In 70 minutes from the first dose the quantities fell to the basis. The vapour exhaled from the lungs increased from 3·12 grs. to 3·76 grs. per minute.

Whisky.—April 6 (6 exps.), Plate XXXVI. fig. 46. 1½ oz. of whisky, spec. grav. ·936 (42 per cent.), in 6 oz. of cold water, caused an average decrease of carbonic acid in myself of ·33 gr., and a maximum of ·7 gr. per minute. The rate of respiration was unchanged, but that of pulsation fell 7 per minute.

April 29 (5 exps.).—2 oz. of the finest whisky, spec. grav. ·875 (69 per cent.), bottled more than twenty years, with water, taken after an experiment on the influence of the vapour of wine, gave an average increase of ·29 gr. of carbonic acid in myself, and ·22 gr. in Mr. MOUL; with maxima of decrease of ·73 gr., and of increase of 1·53 gr. in myself, and a maximum increase of ·78 gr. in Mr. MOUL. My quantity of air was at first increased and then lessened, whilst it varied in Mr. MOUL. The rate of respiration fell, and that of pulsation rose in both. Since the basis quantity in this experiment was due to the inhalation of wine, it is possible that the comparative results thus given may not be quite normal.

May 4 (6 exps.), fig. 47.—2 oz. of the whisky which was used in the first experiment, spec. grav. ·928 (45·5 per cent.), caused an average decrease in carbonic acid of ·57 gr., and a maximum of 1 gr. per minute, whilst in Mr. MOUL the average increase was ·29 gr., and the maximum ·66 gr. per minute. The rate of respiration declined considerably in myself, and, with one exception, in Mr. MOUL also. The rate of pulsation fell in

Mr. MOUL 8 per minute. The quantity of air was reduced in myself 52 cubic inches per minute.

Brandy.—April 20 (6 exps.). 1½ oz. of excellent brandy, with water, caused in me an average decrease of ·2 gr. of carbonic acid, and a maximum of ·38 gr. per minute.

April 24 (6 exps., Plate XXXVI. fig. 52).—2 oz. gave me an average decrease of ·38 gr., and a maximum of ·71 gr. per minute, and to Mr. MOUL ·02 gr. and ·62 gr. respectively; but in him there was, on two occasions, an increase of ·4 gr. per minute. The quantity of air fell 42 cubic inches and 37 cubic inches per minute in myself, and 34 cubic inches per minute in Mr. MOUL. My rate of respiration and pulsation fell on both occasions, whilst in Mr. MOUL the former varied and the latter fell a little.

Gin.—April 27 (6 exps.), Plate XXXVI. fig. 48. 2 oz. of fine old British gin, with 6 oz. of cold water, gave me a maximum decrease of 1·52 gr. of carbonic acid in half an hour, and an average decrease of ·65 gr. per minute in 86 minutes. In Mr. MOUL the average decrease was ·2 gr., and the maximum ·4 gr. per minute. The volume of air was reduced 56 cubic inches in myself, but it was unchanged in Mr. MOUL. The rate of respiration fell in myself, but it varied much in Mr. MOUL; whilst that of pulsation fell 6 per minute in myself, and was unchanged in Mr. MOUL.

Dec. 21 (4 exps.).—The same quantity of newer and probably inferior gin, taken in the afternoon, gave me a maximum decrease of ·46 gr. of carbonic acid and 43 cubic inches of air per minute, the diminution ending in three-quarters of an hour. The rate of respiration slightly fell, whilst that of pulsation rose 5 per minute. There was a decrease in the amount of vapour exhaled from the lungs, from 3·12 grs. to 2·7 grs. per minute (·699 gr. and ·667 gr. to 100 cubic inches).

Rum.—April 8 (6 exps.). 1½ oz. of Navy rum, spec. grav. ·900 (58 per cent.), with water, taken in the afternoon, gave me a maximum increase in carbonic acid of ·78 gr., and an average increase of ·26 gr. per minute, whilst Mr. MOUL had a maximum increase of ·7 gr. per minute. The volume of air was increased 13 cubic inches and decreased 49 cubic inches in myself, and in Mr. MOUL it was decreased 80 cubic inches per minute. The rate of respiration fell, and chiefly in Mr. MOUL; whilst that of pulsation rose in myself and fell in Mr. MOUL. On another occasion, April 10 (7 exps., Plate XXXVI. fig. 49), in the morning, the increase of carbonic acid was much greater, viz. a maximum of 1·24 gr. in myself, and 2·14 grs. per minute in Mr. MOUL. The quantity of air inspired varied in myself, but in Mr. MOUL it was increased 82 cubic inches per minute. My rate of respiration fell, and that of Mr. MOUL fell greatly, and his rate of pulsation fell also. The depth of inspiration was increased in both of us.

April 30 (7 exps.).—2 oz. of very fine old rum, spec. grav. ·875 (69 per cent.), taken in the morning, gave to me a maximum increase in carbonic acid of only ·1 gr., but to Mr. MOUL of 1·5 gr. per minute. There was a maximum increase in the quantity of air of 11 cubic inches in myself, and 40 cubic inches in Mr. MOUL per minute. The rate of respiration fell towards the end of the inquiry in myself, and at an earlier period in Mr. MOUL. His pulsation also fell a little, whilst mine rose.

December 27 (5 exps.), Plate XXXVI. fig. 50.—½ an oz. of only moderately good rum, which had been used in the experiments on inhalation, and so weak as ·944 spec. grav. (37·5 per cent.), with 2 oz. of cold water, taken every quarter of an hour, gave the following increase in the quantity of carbonic acid evolved after each dose:—·14 gr., ·43 gr., ·2 gr., and ·66 gr., showing a continuous increase. The maximum increase in the quantity of air inspired was 49 cubic inches after the last dose, and the proportion of the carbonic acid to the inspired air was somewhat reduced in consequence of the disproportionate increase of the latter. The rate of respiration was slightly increased with the first dose, and as slightly decreased with the subsequent ones, whilst the rate of pulsation was also slightly increased. The amount of vapour exhaled per minute in the expired air varied from a decrease of ·3 gr. and ·2 gr. after the second and third doses, when the respiration felt feeble and there was sighing, to an increase of ·04 gr. and ·06 gr. after the first and fourth doses. There was, however, a progressive decrease to each 100 cubic inches of inspired air, as follows:—·742 gr. (basis), ·7 gr., ·67 gr., ·65 gr., and ·67 gr., after succeeding doses.

Rum and Milk.—April 12 (8 exps.), Plate XXXVI. fig. 51. 1½ oz. of Navy rum, with 1 pint of good new milk, produced in myself and Mr. Moul an average increase in the carbonic acid of ·73 gr. and ·65 gr. per minute, whilst the maxima of increase were ·9 gr. and 1·38 gr. per minute respectively. The quantity of air was increased 25 cubic inches and 18 cubic inches per minute, with a diminution also of 42 cubic inches in the latter (Mr. Moul). The rate of respiration declined, and very much so in Mr. Moul, whilst that of pulsation was increased. The depth of respiration was increased in both.

Sherry Wine.—April 2 (5 exps.), May 5 (5 exps.), May 6 (7 exps.), Plate XXXVI. fig. 53. 3 oz. of tolerably good sherry wine, alone, produced in myself, on two occasions, an average increase of ·19 gr. and ·3 gr., and on another occasion an average decrease of ·32 gr. of carbonic acid per minute. The maxima of increase were ·36 gr. and ·44 gr., and of decrease ·52 gr. per minute on the several occasions. In Mr. Moul the average decrease was ·32 gr., and increase ·926 gr. and ·21 gr. per minute; with maxima of decrease ·9 gr., and of increase 1·44 gr. and ·82 gr. per minute. The quantity of air was lessened in myself in all the inquiries, but chiefly in the first one, and least in the last; whilst in Mr. Moul it varied in the two former and was reduced in the last. The rate of respiration in both fell, and chiefly so in the first experiment; whilst that of pulsation rose in myself, and was unchanged in Mr. Moul.

Inhalation of Alcohols.

I have made several experiments with a view to determine the influence of the volatile matters of wines and spirits when inhaled, but the uneasy feeling in the lungs which followed each experiment made me fear the effect of a too prolonged series. I placed 3 or 4 oz. of the fluid for examination in a Woulfe's bottle, and inspired air at the ordinary temperature which had passed directly over it, taking care to shake the fluid frequently.

Port Wine.—April 29 (4 exps.), Plate XXXVI. fig. 54. The wine was exceedingly fine and old, and the vapour was inspired during 10 minutes, on four occasions, within 70 minutes. The carbonic acid was reduced on the average ·53 gr. in myself, and ·42 gr. in Mr. MOUL per minute, with maxima of decrease of ·87 gr. and ·58 gr. per minute respectively. The maximum decrease in the inspired air was 56 cubic inches in myself, and 36 cubic inches in Mr. MOUL per minute. The rate of respiration was increased in Mr. MOUL, but it was ultimately decreased in myself. A moderately pungent sensation was perceived in the pharynx, and particularly when the wine was shaken. The loss in weight was 40 grs., and the spec. grav. increased from 1·004 to 1·005.

Sherry Wine.—December 15. The bouquet was good but not persistent, and it produced but little effect upon the throat. The effect of my inhaling it during 10 minutes was to reduce the carbonic acid ·12 gr., and the air 8 cubic inches per minute. The vapour exhaled was increased from 3 grs. to 3·66 grs. per minute (·707 gr. to ·88 gr. to 100 cubic inches).

Alcohol.—March 30. Spt. Vini, inhaled 15 minutes, caused during the last 5 minutes a decrease in the carbonic acid of ·34 gr., and in the air of 11 cubic inches per minute. The quantity of vapour exhaled was increased from 3·22 grs. to 4·04 grs. per minute (·755 gr. to ·973 gr. to 100 cubic inches). On another occasion (December 6), the alcohol being inhaled during 10 minutes, there was no variation either in the carbonic acid or air, and the vapour exhaled was increased from 3·3 grs. to 3·9 grs. per minute (·78 gr. to ·91 gr. to 100 cubic inches). The alcohol lost 21 grs. in weight. In both experiments the pulse became fuller.

Gin (British).—December 13. Inhalation of gin during 10 minutes caused a decrease in the carbonic acid of ·5 gr. per minute, whilst there was an increase in the volume of air inspired of 18 cubic inches per minute. The vapour exhaled was increased from 3 grs. per minute to 3·51 grs. per minute (·746 gr. to ·835 gr. to 100 cubic inches).

Rum.—December 4, December 13. Rum, inhaled during 10 minutes on one occasion, and 15 minutes on another, gave a decrease in carbonic acid of ·56 gr. and ·12 gr., and in air an increase of 12 cubic inches per minute. The pulse became much fuller. The vapour exhaled increased from 3·24 grs. to 3·89 grs. per minute (·799 gr. and ·962 gr. to 100 cubic inches), and from 3·12 grs. to 4·4 grs. per minute (·699 gr. to ·943 gr. to 100 cubic inches). In the first experiment the rum lost 17 grs. in weight in ten minutes.

I now proceed to describe the effect of ale and porter.

Stout.—May 7 (7 exps.), Plate XXXVI. fig. 55. 10 oz. of good stout gave to myself and Mr. MOUL an average increase in the carbonic acid of ·83 gr. and ·81 gr., and maxima of 1·56 gr. and 1·02 gr. respectively per minute. The air was increased 41 cubic inches and 46 cubic inches per minute. The rate of respiration was a little increased, and varied somewhat in myself, whilst it fell in Mr. MOUL. The rate of pulsation was increased 4 and 7 per minute. The depth of inspiration was increased 1·6 cubic inch. On another occasion, May 11 (6 exps.), the maximum increase in carbonic acid was 1·16 gr. and ·98 gr.

TABLE showing the amount of variation in the quantity of carbonic acid and vapour exhaled, and of the air inhaled, as also in the rate of respiration and pulsation, &c. in the various experiments on alcohols previously recorded.

The sign + signifies increase and — decrease.

	Myself.								Mr. Moul.						
	Variation in the carbonic acid expired per minute.		Variation in the air inspired per minute.		Variation in the vapour expired per min.	Variation in the rate per minute of		Variation in the depth of inspiration.	Fluid lost.	Variation in the carbonic acid expired per minute.		Variation in the air inspired per minute.		Variation in the vapour expired per min.	Variation in the rate per minute of		Variation in the depth of inspiration.
	Average.	Maximum.	Average.	Maximum.		Respiration.	Pulse.			Average.	Maximum.	Average.	Maximum.		Respiration.	Pulse.	
	gr.	gr.		cub. inch.	gr.			cub. in.	grs.	gr.	grs.		cub. inch.				
Alcohol	+ ·18	+ ·46	...	+47	.....	—											
	+ ·8	+1·64	...	+53	.....	+	...	...	...	.....	+ ·4	...	+26	...	+		
		+ ·74	...	+37	+ ·64	None.	+	...	...	.....	— ·72						
Whisky	— ·33	— ·7	...	.....	.....	None.	—7										
	+ ·29	— ·73	...	+	.....	—	+	...	...	+ ·22	+ ·78	...	Varied.	...	—	+	
		+1·53	...	—													
	— ·57	—1	...	—52	.....	—(Much.)	...	...	...	+ ·29	+ ·66	...	.....	...	—	—8	
Brandy	— ·2	— ·38	...	—42	.....	—	...	...	...	.....	.....	...	.....	...	Varied.		
	— ·38	— ·71	...	—37	.....	—	...	...	...	— ·02	— ·62	...	—34	...	Varied.	—	
											+ ·4						
Gin	— ·65	—1·52	...	—56	.....	—	—6	...	...	— ·2	— ·4	...	0	...	Varied.	None.	
		— ·46	...	—43	— ·42	—(Little.)	+5										
Rum	+ ·26	+ ·78	...	+13	.....	—	+	...	...	.....	+ ·7	...	—80	...	—	—	
				—49													
		+1·24	...	Varied.	.....	—	...	+	...	.....	+2·14	...	+82	...	—(Much.)	—	+
		+ ·1	...	+11	.....	—	+	...	...	.....	+1·5	...	+40	...	—	—	
	+ ·35	+ ·66	...	+49	.....	—	+3	+									
Rum and Milk ...	+ ·73	+ ·9	...	+25	.....	—	...	+	...	+ ·65	+1·3	...	+18	...	—(Much.)	+	+
													—42				
Sherry	+ ·19	+ ·36	...	+Much.	.....	—	+	...	...	— ·32	— ·9	...	Varied.	...	—	None.	
	+ ·3	+ ·44	...	—	.....	—	+	...	...	+ ·926	+1·44	...	Varied.	...	—	None.	
	— ·32	— ·52	...	Least.	.....	—	+	...	...	+ ·21	+ ·82	...	—	...	—	None.	
Vapours.																	
Port Wine ...	— ·53	— ·87	...	—56	.....	—	...	...	40	— ·42	— ·58	...	—36	...	+		
Sherry	— ·12	.....	...	— 8	+ ·66												
Alcohol	— ·34	.....	...	—11	+ ·82	...	Fuller.										
	0	.....	...	.....	+ ·6	...	Fuller.	...	21								
Gin	— ·5	.....	...	+18	+ ·51												
Rum	— ·56	.....	...	.....	+ ·65	...	...	...	17								
	— ·12	.....	...	+12	+1·28	...	Much fuller.										
Stout	+ ·83	+1·56	...	+41	.....	+Varied.	+4	+1·6	...	+ ·81	+1·02	...	+46	...	—		
							+7										
		+1·16	...	0	.....	—	+	+	...	.....	+ ·98	...	+18	...	...	...	+
Ale.....	+ ·6	+1·4	...	+60	.....	None.	None.	...	...	+ ·27	+ ·36	...	—	...	+		

per minute. There was no increase in the quantity of air in myself, but there was a maximum increase of 18 cubic inches in Mr. MOUL. The rate of respiration fell a little, and that of pulsation rose. The depth of inspiration was much increased.

Ale.—May 10 (6 exps.), Plate XXXVI. fig. 56. 11 oz. of good old home-brewed Hertfordshire ale, a little acid, gave an average increase in carbonic acid of ·6 gr. and ·27 gr., and maxima of 1·4 gr. and ·36 gr. to myself and Mr. MOUL respectively. The volume of air inspired was increased 60 cubic inches in myself, but there was a diminution in Mr. MOUL. The rate of respiration and pulsation scarcely varied in myself, and that of respiration was at first increased in Mr. MOUL.

As there was much variation in the action of the substances classed under this head, I have thrown the results now given into the Table on the opposite page, with a view to the more ready comprehension of the numerous details.

Abstract of the Effects of Alcohols.

From the foregoing we may learn—

1. That the presence of alcohol, being one amongst many elements, and that one varying greatly in quantity, is an insufficient ground for classification, and does not give a common action to the members of this class.

2. The *direct* action of pure alcohol was much more to increase than to lessen the respiratory changes, and sometimes the former effect was well pronounced. Small doses repeated had a more uniform and persistent effect than would have followed the administration of the whole at once. The *indirect* action, as, for example, in lessening the appetite for food, and the mode of its action, I have not investigated.

3. Brandy, whisky, and gin, and particularly the latter, almost always lessened the respiratory changes recorded, whilst rum as commonly increased them. Rum and milk had a very pronounced and persistent action, and there was no effect upon the sensorium. Ale and porter always increased them, whilst sherry wine lessened the quantity of air inspired, but slightly increased the carbonic acid evolved.

4. The volatile elements of alcohol, gin, rum, and sherry and port wine, when inhaled, lessened the quantity of carbonic acid exhaled, and usually lessened the quantity of air inhaled. The effect of fine old port wine was very decided and uniform; and it is known that wines and spirits improve in aroma and become weaker in alcohol by age. The excito-respiratory action of rum is probably not due to its volatile elements.

5. The quantity of vapour exhaled from the lungs was increased during the inhalation of the volatile elements of wines and spirits, without the quantity of air having increased. When gin was drank, the quantity of vapour in the expired air was lessened, whilst it was increased under the influence of alcohol, in about the same degree as during the inhalation of that substance. Hence the exhalation of vapour and carbonic acid are not parallel acts.

6. The rate of respiration was in almost all instances lessened in both of us, whilst that of pulsation was as constantly increased in myself, but not in Mr. MOUL.

7. The relation between the quantity of carbonic acid expired and the volume of air inspired, was usually increased at the period of maximum influence.

8. The variation in the results was greater than the statement of the average and maximum effects indicates, as may be seen in the Tables and Plates.

The *general effects upon the system* of these substances may be thus epitomized:—

1. There is not an exact correspondence in time and intensity of the effects upon consciousness, sensibility, and respiration, and their principal influence is not upon the respiratory function. They *disturb* the vital actions.

2. There were two sets of effects in each of the inquiries on spirits.

A. The early effects, consisting of—

Lessened consciousness, with cloudiness, swimming or giddiness, beginning in less than 10 minutes, and increasing during about 30 minutes.

Lessened sensibility to light, sound, and touch.

Wavy or buzzing sensation passing through the whole body; and a semi-cataleptic state, in which there was indisposition to move any part of the body from the then existing position.

These occurred at the same period as:

Lessened voluntary muscular power and control, with sensation of stiffness and hanging of the upper lip, and stiffness of the face and forehead, beginning in 8 minutes, and continuing about 45 minutes. The dartos was relaxed, and the erector penis and the sphincter of the bladder were rendered less effective. The action of the heart and arteries was increased, as was that of the muscles of inspiration, with a sensation of sudden and forcible action, to a greater degree than the quantity of air inspired accounted for. There was certainly a difference in the effect upon the muscles subject to, and not subject to volition.

Lessened transpiration of vapour from the lungs during $\frac{3}{4}$ to 1 hour, with dryness of the skin (as if it had been induced by an east wind), and particularly with rum. Increased arterial action near to the surface in 8 minutes, with heat, tingling and swelling of the skin, and a dry state of the whole mouth, with whisky; and dryness, redness, and soreness of the tip of the tongue with rum.

Pleasant dreaminess and talkativeness, particularly with rum, in 13 to 15 minutes.

B. The later effects.

Taciturnity in from 18 to 80 minutes, followed by depression and a miserable feeling in from 60 to 90 minutes.

Sensation of cold often occurred suddenly and apart from the temperature of the air in about 50 minutes.

The principal influence over consciousness and sensibility was often lessened suddenly, and the effects of the alcohol nearly disappeared at the following periods: 71 to 73 minutes with alcohol; 43 to 120 minutes with rum; 66 to 84 minutes with whisky; 46 to 80 minutes with brandy, and 68 minutes with gin.

6. *The Tea Series.*

The members of this class are nearly all powerful respiratory excitants. The inquiries have been very varied and extensive. The tea was exceedingly good and pure.

Tea.—April 2 (6 exps.), Plate XXXVI. fig. 32. 100 grs. of black tea gave to myself and Mr. MOUL a maximum increase of carbonic acid of ·87 gr. and 1·72 gr. per minute in 50 and 71 minutes. The average increase was ·73 gr. and 1 gr. per minute. The quantity of air was increased 71 cubic inches and 68 cubic inches per minute, and the depth of inspiration 4 cubic inches in each of us. The rate of respiration was increased and that of pulsation decreased, except at the first observation, after the tea had been taken.

April 7 (5 exps.), April 17 (5 exps.), Plate XXXVI. fig. 31, April 19 (5 exps.).—50 grs. of black tea gave the following results to myself, Mr. MOUL, Mr. MOUL's son (æt. 16), and Professor FRANKLAND on different occasions:—a maximum increase of carbonic acid of 1·08 gr. in myself; 1·38 gr., 2·58 grs. and 1·6 gr. in Mr. MOUL; 2 grs. in Mr. MOUL's son, and ·69 gr. per minute in Professor FRANKLAND. The maximum increase in the quantity of air inspired was in the same order,—34 cubic inches, 39 cubic inches, 50 cubic inches, 72 cubic inches, 95 cubic inches, 26 cubic inches per minute. My rate of pulsation was lessened, and that of respiration was scarcely changed. The rate of both was lessened in Mr. MOUL, whilst in his son that of respiration was increased and of pulsation decreased.

May 26 (7 exps.).—100 grs. of green tea, drunk when cold, gave to myself and Mr. MOUL maxima of increase of carbonic acid of ·9 gr. and 2·58 grs. per minute, with average increase of ·44 gr. and 1·57 gr. per minute. The quantity of air was not increased in myself, but it was increased 120 cubic inches per minute in Mr. MOUL. The rate of respiration declined so much as 1·2 and 2 per minute, and in Mr. MOUL that of pulsation also slightly declined. The depth of inspiration was increased 3 cubic inches and 10 cubic inches.

August 26 (4 exps.).—The same quantity given to Mr. HOFFMAN, Surgeon to the Margate Infirmary, caused a maximum increase of ·64 gr. of carbonic acid per minute and 50 cubic inches of air per minute in one hour. The pulsation declined after the first observation.

May 24 (10 exps.), Plate XXXVI. fig. 35.—25 grs. of green tea, drunk when cold several hours after it had been infused, and repeated every quarter of an hour for five times, gave Mr. MOUL an average increase in carbonic acid of 1·2 gr., and a maximum of 1·8 gr. per minute. The maximum increase in the quantity of air inspired was 66 cubic inches per minute after the fifth dose. The total increase of carbonic acid, as deduced from the ten observations, was 193 grs.; but at the end of the inquiry, in two hours and thirty-four minutes, there was still an increase of ·9 gr. of carbonic acid and 36 cubic inches of air per minute. The rate of respiration declined 1·6 per minute, whilst that of pulsation was scarcely changed. The depth of inspiration was increased 10·6 cubic inches, and was much the greatest after the fourth dose.

June 8 (13 exps.), fig. 34.—Mr. MOUL took 150 grs. of black tea infused in one pint of

water, and the whole carbonic acid exhaled by him during the inquiry was collected and weighed every five minutes. The basis quantity was again reached after sixty-five minutes. On the whole average the increase in the carbonic acid was ·79 gr., with a maximum of 1·24 gr. per minute. Thus the excess of the carbonic acid exhaled over the basis quantity was 51·35 grs., or only one-fourth of that resulting from a smaller quantity when divided and taken at intervals. The maximum increase in the quantity of air inspired was 92 cubic inches per minute, and the greatest increase in both the carbonic acid and the air occurred in the first half of the period of inquiry. The rate of respiration was increased in the first three examinations.

May 22 (7 exps.), Plate XXXVI. fig. 33.—I took 100 grs. of black tea and collected all the carbonic acid exhaled under its influence, and weighed all that collected in the first hour, and then each quarter of an hour for three times, and finally in five minutes, when the basis was reached and the inquiry ended. The average increase in the carbonic acid was ·64 gr. and the maximum 1·23 gr. per minute, and thus the total increase in 110 minutes was 70·40 grs. The quantity of air was increased on the average 47·5 cubic inches, and the maximum increase was 77 cubic inches per minute at the end of the first hour. The pulse fell and the rate of respiration slightly increased, whilst the depth of inspiration increased nearly 5 cubic inches.

Tea, Milk, and Sugar.—June 5 (6 exps.), Plate XXXVI. fig. 30. 50 grs. of black tea, taken with milk and sugar, gave us maxima of increase in the carbonic acid of 2·96 grs. and 2·56 grs. per minute. The maximum increase in the quantity of air was 78 cubic inches per minute. There was also increased rate both of respiration and pulsation.

Tea and Citric Acid.—July 9 (7 exps.), fig. 36, July 13 (5 exps.), July 15 (5 exps.), July 13 P.M. (3 exps.), July 12 (5 exps.). 100 grs. of black tea, taken with 30 grs. of citric acid, gave me maxima of increase of carbonic acid in three experiments of 1·86 gr., 1·11 gr., and 1·14 gr. per minute; on another occasion it was only ·88 gr. per minute in Mr. MOUL. The increase in the quantity of air inspired was 72 cubic inches, 60·5 cubic inches, and 72 cubic inches per minute in myself, and 6 cubic inches per minute in Mr. MOUL; but in him there was also a maximum decrease of 18 cubic inches per minute. The rate of respiration and pulsation was always considerably increased in myself, but not in Mr. MOUL.

When taken in the afternoon I had no increase of the carbonic acid, and the effects much more resembled those observed in Mr. MOUL in his experiment before breakfast.

Tea, with Soda and Potash.—July 10 (6 exps.), fig. 37. 100 grs. of black tea, with 50 grs. each of carbonate of soda and potash, with 8 oz. of water, gave me a maximum increase in carbonic acid of 1·08 gr. per minute, and in air 39 cubic inches per minute. The rate of respiration scarcely varied, but that of pulsation was a little increased.

Tea, with Caustic Alkali.—July 22 (5 exps.), fig. 38. 100 grs. of black tea, with 40 ♏ of Liq. Potassæ and 7 oz. of water, gave no increase in the carbonic acid. There was an increase of 27 cubic inches of air. The rate of respiration was unchanged, but that of pulsation fell.

On many occasions we took a cup of tea with a view to relieve the system after experiments with other substances; and the results have much interest, as showing their uniform direction and the rapidity of the action of tea. We both took milk with it, but I alone took sugar.

April 24.—After having taken brandy, tea gave to myself and Mr. MOUL in fifteen minutes an increase of carbonic acid of ·62 gr. and 2·58 grs., and of air 25 cubic inches and 108 cubic inches per minute.

May 16.—After cocoa had increased the respiration in myself, but scarcely in Mr. MOUL, tea gave us an increase in carbonic acid of ·2 gr. and 2·2 grs., and in air of 9 cubic inches and 78 cubic inches per minute.

May 28.—After an experiment on rice, 50 grs. of tea infused one minute, gave Mr. MOUL an increase in carbonic acid of 1 gr., and in air of 17 cubic inches per minute.

May 29.—After having taken whisky, the same quantity of tea infused two minutes, gave us in ten minutes an increase in carbonic acid of ·96 gr. and 1·32 gr. of carbonic acid, and 50 cubic inches and 56 cubic inches of air per minute.

May 30.—After an experiment on rum, tea caused a small decrease in my carbonic acid with a slight increase of air; but Mr. MOUL had in twenty-five minutes an increase of ·92 gr. of carbonic acid and 48 cubic inches of air per minute.

June 21.—After an experiment on arrowroot and butter, I had again a small decrease in the carbonic acid, whilst Mr. MOUL had an increase of 2·12 grs. and 98 cubic inches of air per minute. Neither substance agreed with us.

Coffee.—April 6 (4 exps.), April 9 (6 exps.), April 15 (6 exps.), Plate XXXVI. fig. 39, May 3 (7 exps.), fig. 40. ½ an oz. of good coffee gave to myself and Mr. MOUL, on three occasions, the following increase per minute:—Carbonic acid, ·98 gr. and 1·02 gr., 9 gr. and ·4 gr., 1·16 gr. and 2·54 grs.; air, 36 cubic inches and 14 cubic inches, 40 cubic inches and 34 cubic inches, 35 cubic inches and 84 cubic inches. ¾ of an oz. gave us an increase per minute of carbonic acid, 1·08 gr. and ·82 gr.; and of air, 28 cubic inches and 54 cubic inches per minute. The rate of respiration, but not of pulsation, was increased in myself, whilst in Mr. MOUL the increased rate of both functions was much less than in myself in the first experiment; and in the others there was no increase. The increase in the depth of inspiration was not great.

April 27.—A cup of coffee with milk, after an experiment on gin, gave neither of us any increase of carbonic acid or air within a short period.

May 6.—¾ of an oz. of coffee with milk gave us, after an experiment on wine, an increase in carbonic acid of ·68 gr. and 1·68 gr., and of air 64 cubic inches and 86 cubic inches per minute in thirty minutes.

Chicory.—May 17 (7 exps.), Plate XXXVI. fig. 42. ½ an oz. of chicory with 8 oz. of boiling water, gave to myself and Mr. MOUL a maximum increase in carbonic acid of 1·17 gr. and ·66 gr. per minute, whilst the quantity of air inspired was increased 27 cubic inches and 42 cubic inches per minute. The rate of respiration and pulsation fell considerably in Mr. MOUL, whilst in myself the latter was lessened 1 per minute and the

former slightly increased. The depth of inspiration was increased 4 cubic inches and 6·2 cubic inches.

Cocoa.—April 16 (6 exps.), Plate XXXVI. fig. 43, April 20 (6 exps.). 1 oz. of good cocoa, well boiled in 11 oz. of water, gave me on two occasions a maximum increase in carbonic acid of 1·92 gr. and 1·1 gr. per minute, whilst Mr. MOUL had on one occasion a maximum increase of ·64 gr. There was a maximum increase of air of 27 cubic inches and 61 cubic inches per minute in myself, with an increase of 94 cubic inches in Mr. MOUL. The rate of respiration and pulsation was nearly unaffected in myself, but it fell in Mr. MOUL. The depth of inspiration was increased 3·6 cubic inches and 5·7 cubic inches in myself.

Coffee leaves.—April 16 (6 exps.), Plate XXXVI. fig. 41, April 30 (5 exps.). Mr. HANBURY of Plough Court kindly furnished me with a specimen of coffee leaves, from which a beverage is made in Sumatra. ½ an oz. infused in 10 oz. of boiling water gave me on two occasions a maximum decrease in carbonic acid of ·84 gr. and ·89 gr. per minute, and Mr. MOUL had a decrease of 1·42 gr. per minute. There was a maximum decrease in the quantity of air inspired of 25 cubic inches and 51 cubic inches per minute in myself, and 160 cubic inches in Mr. MOUL. The rate of pulsation and respiration, and the depth of inspiration, all fell in both of the inquiries.

The foregoing experiments prove—

1. That tea, coffee, chicory and cocoa are respiratory excitants, whilst coffee leaves depress the respiratory function.

2. The uniformity in the direction of the results is exceedingly striking, whilst the degree of influence is to a certain extent variable.

3. Tea is the most powerful, then coffee and cocoa, and lastly, chicory.

4. The rate of respiration was sometimes a little increased and at others a little decreased, but the depth of inspiration was always largely increased. The rate of pulsation was usually slightly increased.

5. With the addition of an acid the effect was somewhat lessened, and the rate of both functions was increased to a greater degree than with tea alone.

6. The addition of an alkali also lessened the effect of tea, and a fixed alkali totally destroyed its influence.

7. The action of acids and alkalies varies with the state of the system and in different persons.

8. The addition of sugar and milk in the ordinary way increased the effect.

9. Small doses of tea, frequently repeated, have much greater effect than the total quantity taken at once.

10. Cold tea, and tea infused and kept twenty-four hours, has as much effect as when hot and recently made.

11. Green tea has somewhat more influence than black tea, and particularly in lessening the rate and increasing the depth of respiration.

12. The proportion of the carbonic acid to the quantity of air inspired was always increased at the period of maximum influence.

13. Mr. MOUL experienced much greater effect from tea than myself. He is exceedingly fond of tea, is not fond of coffee, and dislikes acids, and in the above experiments the results corresponded.

14. The influence of both tea and coffee is exerted almost immediately, viz. in five minutes, and the maximum is attained in from twenty-five to sixty minutes. The duration varies from one to two hours. In all these particulars there is a variation in different persons.

15. With tea we frequently found nausea in ten minutes, and sometimes to a very unpleasant degree, but it left in ten or fifteen minutes. There was also a soothing or narcotic effect at first on several occasions, and when it had been taken with an alkali this effect was continued to the end; whilst on the other hand the influence was more stimulating with the acid. There was great freedom of inspiration, and sometimes of expiration also, in about forty to seventy minutes, and with this there was a feeling of lightness and clearness. The pulse was always soft, and the skin moist or soft.

16. With coffee there was no nausea or soothing; the pulse was sometimes feeble, and the pulsation in the head and hands more perceptible. There was often an uncomfortable sensation in the small intestines and forcing at the rectum, and not unfrequently a sense of constriction about the diaphragm in from sixteen to forty minutes. There was more action upon the kidneys than with tea. The skin was often hot and dry.

17. Coffee leaves caused the hands to be hot in seven minutes when 1 oz. had been taken, and in thirty-five minutes a purring sensation occurred similar to that with alcohol, and a not unpleasant feeling of listlessness. The effect was narcotic in thirty-seven minutes.

7. *Some other Nitrogenous Substances.*

Albumen.—April 9 (8 exps.). Two good-sized boiled eggs gave Mr. MOUL'S son an average increase in carbonic acid of ·27 gr., and a maximum of ·88 gr. per minute. The maximum increase in the quantity of air inspired was 17 cubic inches per minute. On another occasion, April 21 (6 exps.), Plate XXXVI. fig. 57, my increase in carbonic acid was an average of ·45 gr. and a maximum of 1·12 gr. per minute, whilst in Mr. MOUL they were ·13 gr. and 38 gr. per minute, respectively. I had a decrease in the quantity of air, whilst Mr. MOUL had an increase of 38 cubic inches per minute. My rate of respiration scarcely varied, but Mr. MOUL'S fell, as did also his pulsation in a slight degree.

Gelatin.—May 8 (6 exps.). The effect of 120 grs. of pure dry isinglass prepared with 12 oz. of water, gave to myself and Mr. MOUL an average increase in carbonic acid of ·43 and ·14 gr., and maxima of ·84 gr. and 66 gr. per minute respectively. On another occasion, May 21 (7 exps.), 100 grs. of dry commercial isinglass gave to myself and Mr. MOUL an average increase in carbonic acid of ·14 gr. and ·26 gr., and maxima of ·76 gr. and ·92 gr. per minute respectively. I had no increase of air in the first expe-

riment, but there was a maximum increase of 14 cubic inches per minute in the second, whilst the increase in Mr. MOUL was 70 cubic inches and 28 cubic inches per minute. The rate of respiration was reduced in both, and the respirations were free and deep. Mr. MOUL is fond of jelly.

Almond-emulsion.—September 16 (6 exps.). 1000 grs. of almonds made into an emulsion with 8 oz. of water, gave me an average decrease in carbonic acid of ·17 gr., and in air of 18 cubic inches per minute. The rate of both pulsation and respiration fell, and there was a semi-narcotic effect in thirty-five minutes. The hands were hot and congested.

Lean flesh.—April 23 (7 exps.). 6 oz. of raw (4½ oz. cooked) excellent lean beefsteak, gave to myself and Mr. MOUL a maximum increase of ·7 gr. and ·2 gr. per minute, but I had no average increase. The maximum increase in the air inspired was 19 cubic inches in myself, whilst there was a decrease in Mr. MOUL. The rate of respiration was reduced.

Fish.—July 5 (8 exps.). 8 oz. of very fine, well cooked salmon, gave me a maximum increase of ·84 gr. of carbonic acid per minute in sixty-five minutes, but there was no average increase. There was a maximum increase of air of 15 cubic inches, with a slight fall in the rate of both respiration and pulsation.

Hence albumen, fibrine, and gelatin exert an influence in exciting the respiratory function—fibrine in the least, and gelatin in the greatest degree. Almond-emulsion, although so powerful a ferment, is not a respiratory excitant.

Conclusion.

Having now described the action of each of the substances mentioned in the list, I proceed to offer a few general remarks upon the results obtained.

1. It is evident that foods may be fitly divided into two classes, viz. those which excite certain respiratory changes (excito-respiratory), and those which do not.

The excito-respiratory are nitrogenous foods, milk and its components, sugars, rum, beer, stout, the cereals, and potato.

The non-exciters are starch, fat, certain alcoholic compounds, the volatile elements of wines and spirits, and coffee leaves.

2. Of the hydrocarbons, sugar must be regarded apart from starch and fat; the former being destructive and the latter conservative of material in the system. Alcohols are allied to both, but chiefly to the latter.

The very similar and powerful action of the cereals, and the uniform and powerful action of milk—substances upon which the life of man chiefly depends—are remarkable, whilst the very feeble excito-respiratory action of pure starch is in accordance with its exceptional use.

No sufficiently distinctive action between fat and starch has been demonstrated, but certain differences have been shown, such as that fat, as compared with starch, less excites the respiration, does not increase the action of starch, increases pulsation somewhat, has a soothing influence, and gives a sensation of satisfaction.

3. Nearly all nitrogenous foods are "excito-respiratory" in various degrees, and they

comprehend nearly all the members of the class. This power is not in a definite proportion to the quantity of nitrogen contained by them, and sugar, which is powerfully "excito-respiratory," is destitute of nitrogen. Probably all compound foods containing sugar or gluten, or both, are "excito-respiratory." The principal ferments are "excito-respiratory."

4. Respiratory excitants have a temporary action; but the action of most of them commences very quickly, and attains its maximum within one hour.

5. The most powerful respiratory excitants are tea and sugar; then coffee, rum, milk, cocoa, ales, and chicory; then casein and gluten, and lastly, gelatin and albumen. The amount of action was not in uniform proportion to their quantity. Compound aliments, as the cereals containing several of these substances, have an action greater than that of any of their elements.

6. Most respiratory excitants, as tea, coffee, gluten and casein, cause an increase in the evolution of carbon greater than the quantity which they supply, whilst others, as sugar, supply more than they evolve in this excess, that is, above the basis. No substance containing a large amount of carbon evolves more than a small portion of that carbon in the temporary action occurring above the basis line, and hence a large portion remains unaccounted for by these experiments.

7. The source of the carbon evolved, whether *directly* from the food recently taken, or *indirectly* from increased action induced in the tissues, or from the more rapid disengagement of that contained in the blood, has not been determined; but it has been shown in reference to the rapidity and amount of action of foods,—

α. That the increase in the evolution of carbonic acid with some of the respiratory excitants is considerable in from three to eight minutes after the introduction of the substance into the stomach, and increases regularly and quickly to a maximum, and then often declines rapidly, as is well shown by tea and sugar. In others, as casein, the action is more tardy.

β. That the effect of alcohols upon the sensorium was often perceived in four minutes after they had been swallowed; and the effect of the inhalation of alcohols over the chemical and physical changes was immediate.

γ. That alkalies usually lessen and prolong their action. That fat and the absence of fluid lessened the action of sugar, whilst acids often increased its action.

δ. That small quantities, often repeated, were more efficacious than one large dose.

ε. Also that the whole of the carbonic acid evolved under the influence of tea, coffee, and gluten, could not have been derived from those substances.

It is remarkable that starch and fat, which constitute the chief supply of carbon to the system, scarcely increase the respiratory changes beyond the amount in which they are found in the absence of food. This may help in the elucidation of their intermediate transformations. Fat never, and lactic acid seldom, increases the respiration above the minimum line. Grape-sugar is a less powerful respiratory excitant than any other kind of sugar; but I have not determined its influence when given in the doses in which

it may be presumed to be given to the respiration as the result of chemical transformations within the body.

Starch and fat maintain the respiration to the minimum line, and only under the influence of exertion or of some other respiratory excitant is that amount much exceeded.

8. Pulsation and respiration, carbonic acid and vapour in the expired air, do not respectively move in parallel lines. There is a close but not absolutely uniform relation between the quantity of air inspired and the carbonic acid expired. There was almost always a parallel movement between them.

9. Very generally there was an increase in the quantity of carbonic acid in relation to the air inspired.

10. The depth of inspiration was almost always increased; and never with food was increased quantity of air inspired, or of carbonic acid expired, due to increased rate of respiration. The rate usually declined and the depth increased.

11. In reference to alcohols, it must be remarked—

α. That alcohol alone was not used in the whole of PROUT'S and VIERORDT'S experiments, but various substances containing alcohol were taken by the former, and white wine by the latter.

β. There is the utmost variation in the composition and quality of the members of this class, so that in reference to wines and spirits, and perhaps alcohol, it would be impossible to obtain two precisely similar specimens from different supplies.

γ. There is great variation in the habits of men, and therefore of inquirers in reference to their use. COATHUPE states that he took one pint of wine at dinner, and occasionally a glass of weak brandy and water at night. PROUT states "that the quantity I am in the habit of taking is very small." Mr. MOUL and myself scarcely ever take spirits; and I rarely take wine or ale, but Mr. MOUL takes three glasses of good wine daily.

δ. Our experiments were made when fasting.

Hence there are many causes for discrepancy in the results of different observers. It is in accord with common observation that different members of this class have different effects; and it is not the practice in medicine to substitute alcohol for wine, brandy, or ale in the proportion in which it is found in those substances. The preference of rum to gin, or other spirits, for the use of the navies of all countries is probably, at the present day, based more upon their different action than upon their relative cost.

12. Tea also varies much in quality, and the effect of different weights of it varies much also. These circumstances have not been recorded in connexion with previous inquiries.

Its powerful, uniform, and rapid excito-respiratory action without increasing pulsation and without supplying much carbon, renders it worthy of being more highly regarded as a medicinal agent. Its efficient action when cold, and after having been infused for many hours, and even days, and its accumulative influence with repeated doses, increase its value.

It is probable that coffee leaves have valuable medicinal properties. The contrast in the effect of tea, and such alcohols as brandy, gin, and whisky, upon the respiration, consciousness, sensibility, muscles, skin, and mucous membranes and pulsation, and the power of regulating the heat of the body, is very striking, and shows that the two classes of substances are applicable to very different conditions.

13. The different action of milk and its components upon Mr. MOUL and myself is instructive; and in general these experiments have shown that there is a direct relation between the idiosyncrasies of individuals in the enjoyment of certain articles of food and their effect upon the system, or in other words, that they are not merely prejudices, but have a relation to the state of the body. I enjoy every kind of food, whilst Mr. MOUL dislikes many, but in such a manner that, with the avoidance of certain members of a class, as respiratory excitants, he had an unusual relish for others of the *same* class.

As some of the results at which I have arrived are not in accordance with those obtained by some other observers, I have felt it to be a duty to carefully reconsider my own labours, and to make myself familiar with the methods adopted by those with whom I differ; and after doing so, I find no reason to distrust the truthfulness of my own observations.

As Dr. PROUT, forty-five years ago, simply sought to determine the per-centage of carbonic acid in the expired air, without being apparently aware that that would not give the total quantity of carbonic acid evolved in any given period, whilst I have determined the latter only, our results cannot be compared; but as I think that he is not always correct, even in reference to the per-centage amount of carbonic acid, I venture to ask attention to the following circumstances:—

He compares the results obtained with standard quantities for each hour, most of which are "only the result of estimation;" and when they were observed quantities, they were derived from a limited number of inquiries upon himself, and evidently without a due appreciation of the varying effects due to the meals and the duration of the intervals between the meals. He states that the results were not in accordance with those of Mr. BRANDE, and were quite unexpected by him. There were also remarkable oscillations; and when the alcohols had induced yawning, the quantity of carbonic acid was found to be much above the standard.

In one experiment only was alcohol taken, whilst wine in different quantities, and porter, with and without food, were taken in other experiments.

He also states that the inspirations and expirations were somewhat deeper than natural, and that "the results obtained are evidently to be understood as measures of the *capability* of the organs of respiration to form carbonic acid at any given time, and not as measures of the *quantity* of it *formed* in a given time."

In reference to M. BOEKER'S experiments, I cannot but attach weight to some of the objections made by me at the commencement of this paper; and although I cannot fully explain the cause of the discrepancy in our results, I think that the decided and uniform

action of sugar, tea, and coffee, in my experiments, affords indisputable evidence of their truthfulness. He classes sugar, coffee, and alcohol together; and although the class of alcohols is a difficult one for investigation, and consists of substances which are known to vary in their action, the truthfulness of my results in reference to two of the three, in opposition to those obtained by M. BOEKER, is presumptive of the truthfulness of the third.

EXPLANATION OF THE PLATES.

PLATE XXXV.

Represents the effect of numerous articles of food when taken in moderate doses alone, fasting, and under precisely the same circumstances, upon the carbonic acid expired, the air inspired, the depth of inspiration, and the rate of pulsation and respiration. They are arranged in four series: viz. Fats, figs. 1 and 2; the Starch Series, figs. 3 to 13; the Milk Series, figs. 14 to 21; and the Sugar Series, figs. 22 to 29.

PLATE XXXVI.

Represents similar inquiries in reference to articles arranged in the Tea Series, figs. 30 to 43, and in the Alcohol Series, figs. 44 to 56; and also the effect of Albumen.

In the construction of these two Plates the *absolute quantities* have not been delineated, but only the increase or decrease from the quantities ascertained immediately before the food was taken. These latter quantities are regarded as basal quantities, and they are stated in figures near the basal line of each object of inquiry in each experiment. Thus in fig. 47, "S. 8·33" and "M. 7·98" placed under the basal line of the carbonic acid, show that before the tea was taken Dr. SMITH expired 8·33 grains, and Mr. MOUL 7·98 grains of carbonic acid per minute; and the direction of the curves shows how far the quantity at each inquiry exceeded the basal quantity. The period at which each inquiry was commenced after the food had been taken is stated in hours and minutes at the head of each column. Each inquiry was continued during five minutes after the period just mentioned; but in some experiments it was continuous for one hour, and followed by others at intervals, as in fig. 33, or was continued without intermission until the end, but the quantities recorded every five minutes, as in fig. 34. In figs. 24, 25, 35, 45, and 50, the dose of the food was repeated more or less frequently during the experiment, and then the figures at the head of each column show the period when the inquiry was made after the repetition of each dose.

The temperature and the height of the barometer are recorded at the head of each figure.

Dotted Line. Dr. Smith.
Black Line. Mr. Moul.

0.06103 Cubic Inches = 1 Cubic Centimetre.

Diagram shewing

1858.

Fats.

1	2
Cod Oil 1 oz.	Butter 500 grs. alone.
P.M. May 8.	A.M. June 25.
	Ther. { 63. 3° wet / 68. 8° dry
	Bar. 29. 81 inches

Starch

3	4	5	6	7	8
Arrow Root 500 grs.	Arrow Root 500 grs. & Butter 1 oz.	Arrow Root 500 grs. Sugar 250 grs.	Wheat Starch from 4 oz. of flour.	Bread White 4 oz.	Gluten 4 oz. fine flu
A.M. June 19.	A.M. June 21	Sep. 13.	A.M. June 24.	A.M. May 13.	A.M. June
65. 2°			S. 63. 5° wet	53. 5°	75. 5°
68°	70° dry	66° dry	68. 1	55°	78. 5°
			29. 86 in.	29. 26	29. 55

Period of each observation after taking the food. hours / minutes

10 30 46 1 1 2 1 31 0 7 16 31 45 1 1 1 2 16 31 9 23 36 48 60 76 91 8 23 38 53 1 1 0 13 10 25 40 60 1 1 22 40 6 18 29 40 1 1 1 0 15 30 30 35 55 65 80 95 5 19 35 54 1 1 6 16

Carb: Acid per minute grs.

Carb: Acid, grs. per minute

Basis grs. per minute

S. 8. 14 S. 7. 9 S. 8. 4 M. 6. 3 S. 8. 6 M. 5. 9 S. 7. 69 S. 8. 22 S. 9. 34 M. 7. 18 S. 8. 06

Depth of inspiration cubic inches

Depth of Inspiration, Cub: ins.

Basis cubic inches

S. 36 S. 38. 4 M. 29. 3 S. 36. 1 M. 28. 2 S. 35. 3 S. 34. 8 M. 30. 1 S. 37. 2

Air inspired per minute: cubic inches

Air inspired Cub. ins. per minute

Basis cubic inches

S. 486 S. 410 S. 438 M. 370 S. 434 M. 350 S. 414 S. 440 S. 551 M. 456 S. 410

Pulsation per Minute

Pulsation per minute

Basis

S. 71 M. 81 S. 71 M. 74 S. 68 S. 73 M. 88 S. 72

hewing the influence of various kinds of Food over the Carbonic Acid expired, & the qu

Series.

8	9	10	11	12	13	14	15	16
Gluten in fine flour.	*Rice 3 oz.*	*Oatmeal Dr S. 4 oz. Mr M. 3 oz.*	*Oatmeal 4 oz.*	*Potatoe (Old) 8oz. boiled.*	*Potatoe (New) 8oz. boiled.*	*Milk (New) 1 pint.*	*Milk skimmed 1 pint*	*Cream 2 oz.*
A.M. June 16.	*A.M. May 13.*	*A.M. Apl 26.*	*P.M. July 9.*	*P.M. May 17.*	*A.M. July 21.*	*A.M. S. Apl 23.*	*June 9.*	*A.M. June 22.*
75.5°	*53.5°*	*58.5° wet*	*61° wet*	*60.7°*		*M. „ 8.*	*67.5°*	*70°*
78.5°	*55°*	*59° dry*	*62.8 dry*	*61.5°*			*70.5°*	
29.55	*29.26*		*29.42*	*29.53*				

S.8.9 M.6.34

S.8.11 M.6.

S.7.

S.9.11

S.7.7

S.7.98 M.8.6

S.806 M.6.36

S.8.26 M.6.3

S.36.7 M.28.7

S.33.1 M.28.4

S.37.8

S.36

S.32.8 M.29

S.34.5 M.30.7

S.37.7 M.28.7

S.455 M.362

S.438 M.392

S.400

S.435

S.383

S.474 M.506

S.414 M.400

S.423 M.374

S.63 M.80

M.80

S.73

S.74

S.69

S.71 M.80

S.73 M.89

S.72 M.80

the quantities of Air inspired, with the Depth of Inspiration & the rate of pulsation.

Milk Series.

16	17	18	19	20	21	22	23	24
Cream 2 oz.	*Casein in 1 pint Skimmed Milk.*	*Casein Lactic Acid 40 m*	*Lactic Acid 40 m*	*Sugar of Milk 250 grs.*	*Sugar of Milk 250 grs. Lactic Acid 40 m*	*Cane Sugar 1½ oz.*	*Cane Sugar 1½ oz.*	*Cane Sugar Water both repeated*
M. June 22.	*A.M. June 10.*	*A.M. June 14.*	*June 7.*	*A.M. June 12.*	*A.M. June 15.*	*A.M. May 1.*	*A.M. Apl. 14.*	*A.M. M*
70°	*70 . 5° 67 . 5°*	*73° 29°. 5 in*	*63° 67°*	*68 . 2° dry 72°*	*76° 29 . 6 in.*	*54° 55° 28 . 625*	*47° 47 . 5°*	*59 . 60 . 29 .*

3 43 59 | 1 1 16 31 | 9 23 39 53 | 1 1 1 7 21 28 | 8 18 30 41 51 | 1 1 1 6 21 35 | 5 19 34 48 | 1 1 1 3 19 36 | 4 17 32 49 | 1 1 1 0 13 29 | 6 19 30 47 57 | 1 1 1 10 20 35 | 10 25 40 55 | 1 1 1 11 30 45 | 12 27 42 57 | 1 1 12 32 | 8 23 35 49 | 1 1

S.8.26 M.6.3 — S.7.68 M.6.44 — S.7.99 — S.8.78 M.6.46 — S.8.66 M.6.38 — S.8.36 — S.9.06 M.6.29 — S.9.46 M.7.7 — S.7.98 M.7.86

7 8.7 — S.37.1 M.30.3 — S.36.3 — S.35.2 M.28.8 — S.37.1 M.27.8 — S.37.5 — S.34.3 M.25 — S.32 M.27.6 — S.36.9 M.32

423 374 — S.405 M.394 — S.422 — S.451 M.346 — S.430 M.365 — S.420 — S.478 M.352 — S.556 M.482 — S.450 M.404

S.68 M.82 — S.74 — S.67 M.78 — S.72 M.81 — S.75 — S.69 M.79 — S.77 M.85 — S.71 M.76

on.

Sugar Series.

1858.

24	25	26	27	28	29
Cane Sugar ½oz. Water 3oz. both repeated in 1 hour.	Cane Sugar ½oz. Water 3oz. In 1 hour ½oz. of Sugar dry. In 1 hour more 3oz. of Water only	Cane Sugar 750grs. Vinegar 6 drms.	Cane Sugar 750grs. Liq. Potass. ♃.	Cane Sugar 750grs. Butter 1oz.	Grape Sugar 500grs.
A.M. May 18.	P.M. May 10.	A.M. June 29.	A.M. July 5.	A.M. July 1.	A.M. July 2.
59 . 50	58 . 80	62°	62 . 8°	62°	59 . 4°
60 . 50	61 . 30	63.8°	62 . 8°	64.4°	61°
29 . 46	29 . 58	29.65	29 . 35		29 . 65

hours / minutes — Period of each observation after taking the food

Carb. Acid, grs. per minute

Depth of Inspiration Cub: ins.

Air inspired Cub: ins. per minute

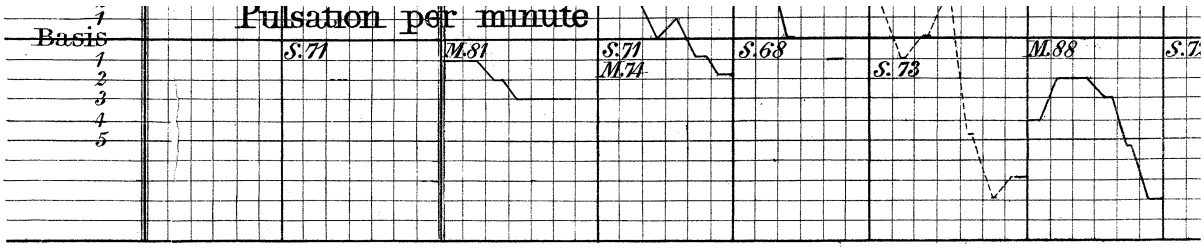
Pulsation per minute

S.7.98 M.7.86 | S.8.38 | S.78 | S.7.36 | S.8.06 | S.7.92

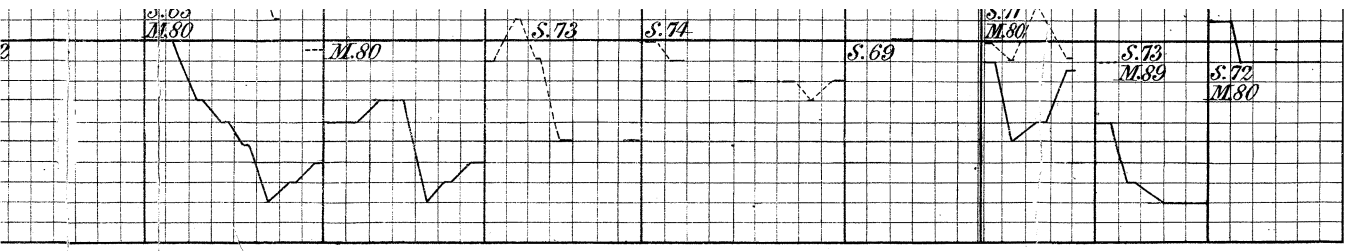
S.36.9 M.32 | S.37.3 | S.36.3 | S.35 | S.35.7 | S.36

S.450 M.404 | S.440 | S.407 | S.384 | S.407 | S.397

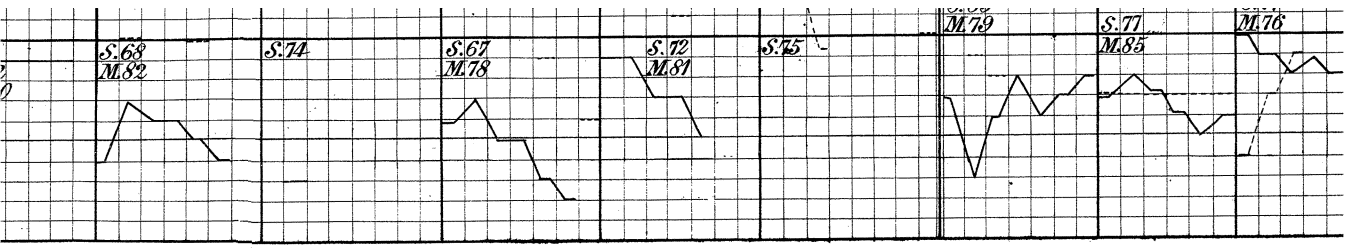
S.71 M.76 | S.69 | S.66 | S.69 | S.66 | S.73



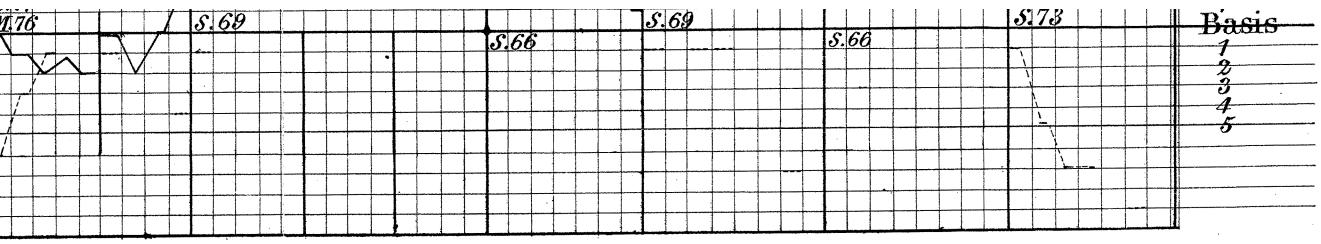
The numbers near each basis line are the basal quantities. S. signifying Dr Smith, & M



Mr. Moul. The minutes at which each experiment was made after the food had been taken are recorded at the h



at the head of each figure, as are also the temperature with the Wet & Dry Bulbs (Fahrenheit) and the Barometr



arometric indications.

Black line. Mr. Moul.
Line. Mr. F. Moul.

Diagram shewing the int

T e a S

1858.

30	31	32	33	34	35
Tea Sugar & Milk	Tea 50grs.	Tea 100grs.	Tea (black) 100grs. Continuous enquiry.	Tea (black) 150 grs. Continuous enquiry.	Tea (Green) cold. 25 Grains taken every ¼ hour 6 times.
A.M. June 5.	A.M. Apl 17.	A.M. Apl 2	A.M. May 22.	A.M. June 8.	A.M. May 24.
Ther: (29.63 wet	63 . 1°	51°	61 . 5°	65 . 6°	58 . 5°
Ther: dry	69 . 1°	53 . 5	63 . 5°	68 . 3°	61°.
Bar. inches	29 . 45			29 . 5	

Period of each observation after taking the food: hour / minutes

8 27 42 1 15 29 | 10 26 40 55 70 | 10 30 50 11 30 50 | " " " " 15 30 45 | 5 10 15 20 25 30 35 40 45 50 55 60 5 10 15 20 | 5 5 5 6 5 5 20 35 50

Carb: Acid per minute grs.

Carb: Acid, grs. per minute

Basis grs. per minute

S. 7.74 M. 6.26 | F.M. 7.3 M. 6.1 | S. 8.33 M. 7.98 | S. 6.97 | M. 6.84 | M. 6.36

Depth of inspiration cubic inches

Depth of Inspiration, Cub: ins.

Basis cubic inches

S. 36.7 M. 26.8 | F.M. 23.8 M. 27.9 | S. 32.4 M. 29.9 | S. 30.5 | M. 35 | M. 30.1

Air inspired per minute cubic inches

Air inspired, Cub: ins. per minute

Basis cubic inches

S. 433 M. 354 | F.M. 397 M. 442 | S. 493 M. 454 | S. 38.5 | M. 366 | M. 388

Pulsation per minute

Pulsation, per minute

Basis

S. 68 M. 77 | F.M. 80 M. 80 | S. 69 M. 71 | S. 8.3

the influence of various kinds of Food over the Carbonic Acid expired, & the quantities

Series.

35	36	37	38	39	40	41	42	43	44
(w) cold. taken every 6 times.	Tea black 100grs. Citric Acid 30grs.	Tea 100grs Potass bicarb. 50grs. Soda. Sesq. 50grs.	Tea 100grs. Liq. Potass & Oil.	Coffee ½ oz.	Coffee ¾ oz.	Coffee leaves ½ oz.	Chickory ½ oz.	Cocoa 1 oz. Water 11 oz.	Alcohol
ay 24.	July 9.	July 10.	July 22.	A.M. Apl 15.	A.M. May 3.	P.M. Apl 16.	A.M. May 17.	A.M. Apl 16.	P.M. May
5°	61°	58 . 8°	66 . 5°	53°	53°		60 . 5°	57 . 5°	57 . 5
	61°	59 . 8°	67 . 8°	54°	53 . 3°		62 . 5°	58 . 5°	29 . 82
	29 . 4		29 . 52		29.				

5 20 35 50 1 4 | 14 28 43 54 1 5 1 16 | 3 14 28 43 53 1 8 | 3 14 27 42 59 | 15 31 45 1 0 1 15 1 30 | 9 24 41 56 1 9 1 25 1 41 | 16 30 45 1 0 1 18 1 40 | 7 22 36 51 1 8 1 24 1 42 1 57 | 14 29 44 59 1 14 1 29 | 9 23 44 58 1 11

S.7.9 | S.7.64 | S.7.68 | S.8.14 M.6.9 | S.8.76 M.6.66 | S.9.2 M.7.5 | S.9.1 M.7.3 | S.8.3 M.7.2 | S.8.24 M.6.8

S.36.3 M.21.2 | S.38.2 M.27.4 | S.36.8 M.27.9 | S.35.2 M.26.4 | S.36.8 M.24

S.35.9 M.27.3

S.332 | S.391 | S.363 | S.517 M.438 | S.458 M.376 | S.518 M.450 | S.453 M.386 | S.501 M.444 | S.471 M.352

S.65 | S.68 | S.75 | S.76 M.80 | S.63 | S.75 M.94 | S.66 M.78 | S.76 M.87 | S.72 M.83

PER.

ntities of Air inspired, with the Depth of Inspiration & the rate of pulsation.

A l c o h o l S e r i e s.

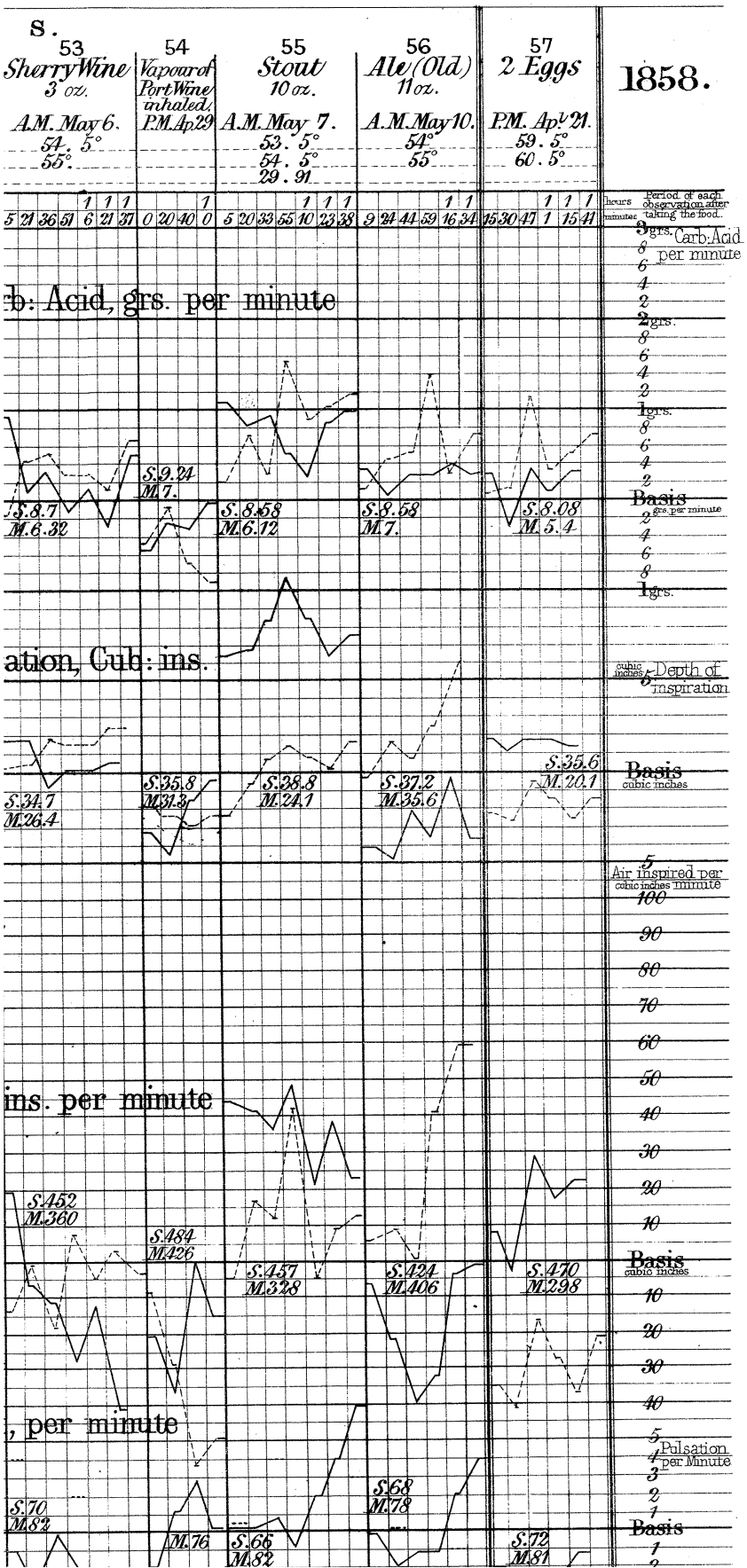
44	45	46	47	48	49	50	51	52	53
Alcohol 1½oz.	*Alcohol ½oz. Sp.Gr. 858 repeated each ½ hour.*	*Whiskey 1½ oz.*	*Whiskey 2oz. 40 years old.*	*Gin (Booths) Old. 2 oz.*	*Rum (Navy) & Water. 1½ oz.*	*Rum ½oz. repeated each ¼ hour.*	*Navy Rum & Milk. 1½ oz. & 20 oz.*	*Brandy 2oz. Water 6oz.*	*Sherry 3 oz*
P.M. May 6.	*P.M. Dec. 27.*	*P.M. Apl 6.*	*A.M. May 4.*	*Apl 27.*	*A.M. Apl 10.*	*P.M. Dec. 27.*	*A.M. Apl 12.*	*A.M. Apl 24.*	*A.M. Ma*
57. 5°			*52. 5°*	*56. 5°*	*47. 3°*	*47°*	*48. 5°*	*60. 6°*	*54.*
29. 825			*53°.*	*58°.*	*48. 5°*	*28. 94*	*49°.*	*63. 6°*	*55°.*

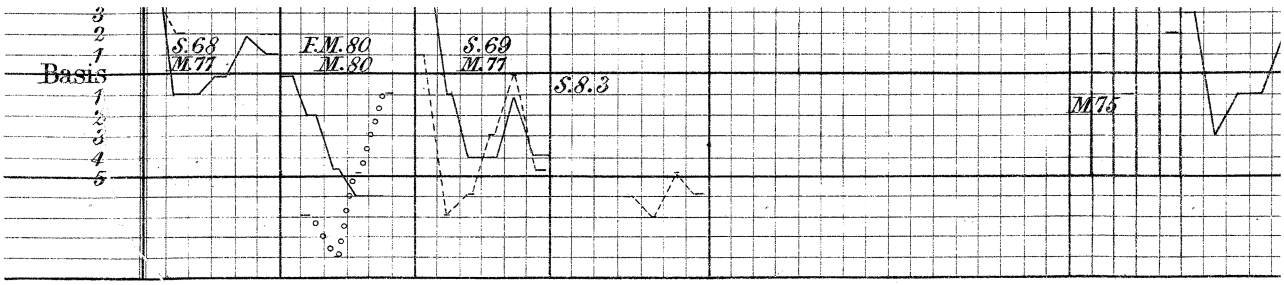
Carb: Ac

Depth of Inspiration,

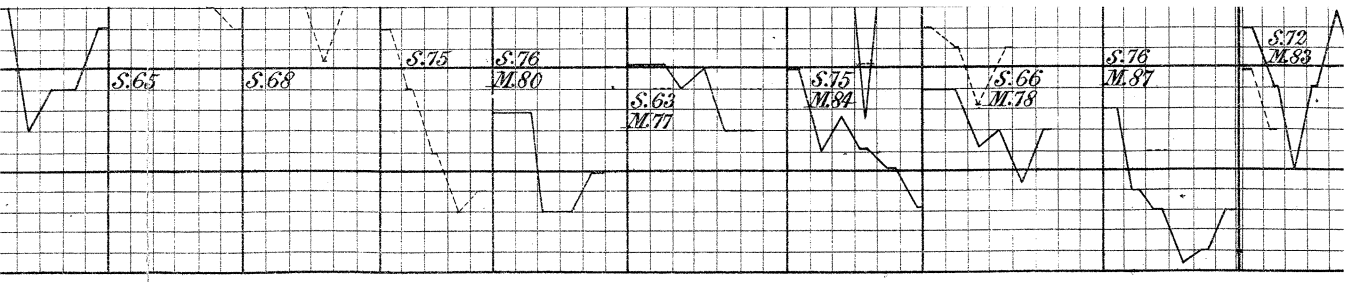
Air inspired, Cub: ins. pe

Pulsation, per

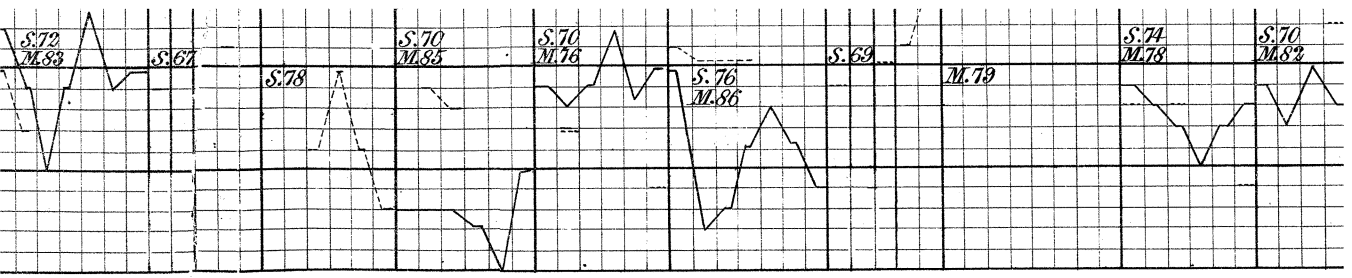

S.
53
Sherry Wine
3 oz.
A.M. May 6.
54. 5°
55°
54
Vapour of Port Wine inhaled.
P.M. Ap 29
55
Stout
10 oz.
A.M. May 7.
53. 5°
54. 5°
29. 91
56
Ale (Old)
11 oz.
A.M. May 10.
54°
55°
57
2 Eggs
P.M. Apl 21.
59. 5°
60. 5°
1858.
hours
minutes
Period of each observation after taking the food.
grs. Carb. Acid per minute
b. Acid, grs. per minute
S.9.24
M.7.
S.8.7
M.6.32
S.8.58
M.6.12
S.8.58
M.7.
S.8.08
M.5.4
Basis
grs. per minute
ation, Cub: ins.
cubic inches
Depth of inspiration
S.34.7
M.26.4
S.35.8
M.31.3
S.38.8
M.24.1
S.37.2
M.35.6
S.35.6
M.20.1
Basis
cubic inches
Air inspired per minute
ins. per minute
S.452
M.360
S.484
M.426
S.457
M.328
S.424
M.406
S.470
M.298
Basis
cubic inches
, per minute
Pulsation per Minute
S.70
M.82
M.76
S.66
M.82
S.68
M.78
S.72
M.81
Basis



The numbers near each basis line are the basal quantities. S. signifying Dr. Smith,



Smith, & M. Mc. Moul. The minutes at which each experiment was made after the food had been taken a



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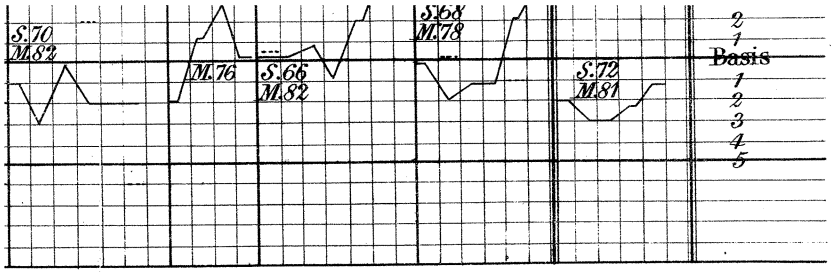

s (Fahrenheit) and the Barometric indications.

Dotted Line. Dr. Smith.
Black Line. Mr. Moul.

0.06103 Cubic Inches = 1 Cubic Centimetre.

Dr. E. SMITH'S PAPER.

Diagram showing the influence of various kinds of Food over the Carbonic Acid expired, & the quantities of Air inspired, with the Depth of Inspiration & the rate of pulsation.

The numbers near each basis line are the basal quantities. S. signifying Dr. Smith, & M. Mr. Moul. The minutes at which each experiment was made after the food had been taken are recorded at the head of each Figure, as are also the temperature with the Wet & Dry Bulbs (Fahrenheit) and the Barometric indications.

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Black Line. Mr. Moul.
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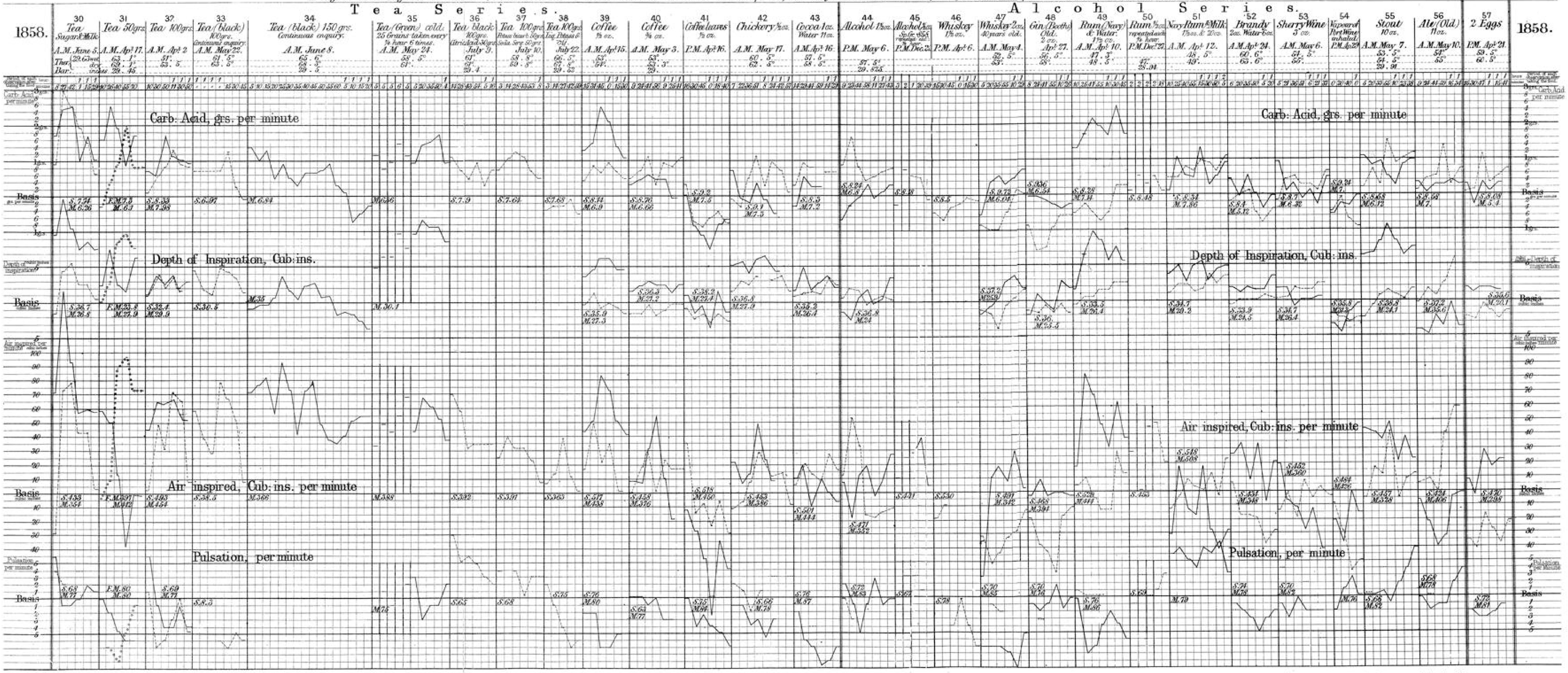

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