**An inquiry into the general pathology of scurvy / by Charles Henry Ralfe.**

# AN INQUIRY

INTO THE

# GENERAL PATHOLOGY OF SCURVY.

BY

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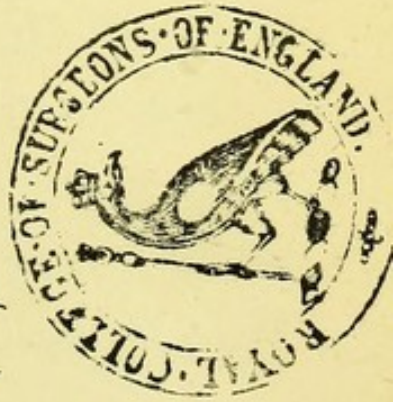


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# GENERAL PATHOLOGY OF SCURVY.

ALTHOUGH no fact in medicine is more clearly established than that the exclusive cause of scurvy is the prolonged and complete withdrawal of succulent plants and fruits from the dietary of those affected, and that the administration of such articles in sufficient quantities is effectual to prevent an outbreak of the disease or to remove it when it occurs, yet we are still in ignorance of the precise nature of the alterations of the blood and tissues which follow, in consequence of this withdrawal of vegetable food. Our ignorance in this respect is mainly due: first, to the incomplete information physiological chemistry affords on many points connected with the variations that daily and hourly occur in the composition of normal blood, and the influence these variations have upon the nutrition of the tissues—points that must be determined before we can expect to judge of the effects produced by even primary alteration of the blood in disease; secondly, to the inquiry having as yet been limited to the determination of a few isolated

facts, and nothing approaching a systematic investigation having been attempted. The most important contributions hitherto made to our knowledge of the pathology of scurvy are those by Mr. George Busk and Dr. Garrod. To the former gentleman* we are indebted for a series of analyses of the blood in scurvy, showing that there is considerable diminution of the red corpuscles, an increase in the amount of fibrin and albumen, and no decrease in the total quantity of the inorganic salts—a view that had been previously maintained. Unfortunately, however, Mr. Busk did not complete his observations by a separate determination of each inorganic constituent. This omission is the more to be regretted as it is now much more difficult to obtain blood in sufficient quantities for analysis than in

* Analyses of blood in scurvy, by Mr. G. Busk, F.R.S., and published originally in Dr. Budd's article on Scurvy in the Library of Medicine:—

TABLE I.

*In* 1,000 *Parts of Blood.*

| — | Water. | Red Globules. | Fibrin. | Albumen. | Salts. |
|---|---|---|---|---|---|
| Normal Blood . . . | 788·8 | 133·7 | 3·3 | 67·2 | 6·8 |
| Scurvy (1) . . . . | 849·9 | 47·8 | 6·5 | 64·0 | 9·5 |
| Scurvy (2) . . . . | 835·9 | 72·3 | 4·5 | 76·6 | 11·5 |
| Scurvy (3) . . . . | 846·2 | 60·7 | 5·9 | 74·2 | 10·9 |

days when bleeding was general and regarded as part of the ordinary treatment. In 1848,† Dr. Garrod, observing that in scorbutic diets potash existed in smaller quantities than in antiscorbutic ones, was led to determine the amount of that substance in the blood and urine of a patient suffering from scurvy, and he found it to be considerably diminished. From this observation he brought forward the theory that scurvy depended upon a deficiency of potash in the system. The result of my analyses confirms the fact observed by Dr. Garrod, that potash is considerably diminished in the urine of patients suffering from scurvy, or when fresh vegetable food is withheld even for a short time in the normal state; but I am hardly disposed to go as far as Dr. Garrod in thinking the disease is produced mainly by a deficiency of that base in the system. The administration of large quantities of strong beef-tea, containing more potash than the ordinary antiscorbutic dietary of the hospital affords, fails to exercise a curative effect, and it is not till the patient receives his lime-juice or potato that he recovers, although tak-

† Dr. Garrod on the Nature, Causes, and Prevention of Scurvy. (*Edinburgh Monthly Journal of Medicine*, new series, vol. ii., p. 457).

ing actually less potash than before. Dr. Buzzard, who has ably reviewed the whole of this question in his article on Scurvy in "Reynold's System of Medicine,"* has suggested that although the organic acids and potash separately do not represent the requisite material, it is to be found in the chemical combination of the acid and the base. As the result of my own observation, I would venture to extend this hypothesis a step further, and say that the primary alterations in scurvy seem to depend on a general alteration between the various acids, inorganic as well as organic, and bases found in the blood, by which—(*a*) the neutral salts, such as the chlorides, are either increased relatively at the expense of the alkaline salts; or (*b*) that these alkaline salts are absolutely decreased.† In the present inquiry I propose to consider—(1) the physiological effect the withdrawal of succulent vegetable food for some time from the dietary has on the variations and relations of the various urinary constituents; (2) to contrast these variations with those that occur when disease is established (the pathological effect); (3) to see

* Vol. i., p. 731.

† The salts of the vegetable organic acids are converted by oxidation in the body into alkaline carbonates.

how far these variations correspond to differences that exist in the chemical composition of "scorbutic" and "antiscorbutic" diets respectively. We shall then, I venture to hope, be in a better position to judge whether the changes which occur in the blood and tissues are brought about—(*a*) by physical agency, as from the withdrawal in bulk of some special constituent; or (*b*) are due to some chemical alteration (as, for instance, diminished alkalinity) in the quality of the blood.

1. *The physiological effect of the withdrawal of fresh vegetable food on the composition of the urine.*—In the following table I have given the analysis of the twenty-four hours' urine of a healthy person living on mixed diet, and also the analysis of the twenty-four hours' urine of the same person after the complete withdrawal of all succulent vegetable food for eighteen days, the diet during those eighteen days consisting of fresh meat, occasionally salted, peas, rice, toast, biscuit, butter, tea, sugar, and a little milk (no salt meat was taken for two days previous to the experiment). About four ounces of meat extra was taken daily in lieu of potatoes.

TABLE II.

*Showing the physiological effect of the withdrawal of fresh vegetables on the composition of the urine.*

| Mixed Diet. | | Eighteen days without Vegetables. | |
|---|---|---|---|
| Quantity | 1480 c.c. | Quantity | 1850 c.c. |
| Specific gravity | 1·018 | Specific gravity | 1·017 |
| Free acid | 1·6 | Free acid | 2·6 |
| Urea | 32·5 | Urea | 55·7 |
| Uric acid | 0·69 | Uric acid | 1·4 |
| Chlorine | 6·7 | Chlorine | 9·2 |
| Sulphuric acid | 3·1 | Sulphuric acid | 3·6 |
| Phosphoric acid (in combination with lime and magnesia) | 0·8 | Phosphoric acid (in combination with lime and magnesia) | 1·2 |
| Phosphoric acid (in combination with potash and soda) | 2·1 | Phosphoric acid (in combination with potash and soda) | 1·5 |
| Potash | 2·3 | Potash | 1·7 |
| Soda | 2·8 | Soda | 4·4 |

The results obtained are in accordance with those of previous observers on the effect produced on the urine by the withdrawal of the principal non-nitrogenous elements of the food.* The water, as well as the solid constituents of the urine, with the exception of the alkaline phosphates and potash, are increased. Thus the quantity of free acid passing out of the system is more

* *Physiological Chemistry.* C. G. Lehmann. Cavendish Soc. Translation, vol. ii., p. 446.—*Composition of the Urine in Health and Disease.* Ed. A. Parkes, M.D., F.R.S., p. 57. Churchill. 1860.

than doubled, the urea is increased more than a third, the uric acid is doubled, the chlorine is increased nearly a third, the sulphuric acid a sixth, and the phosphoric acid, in combination with the earthy bases, increased a third, whilst the phosphoric acid in combination with the alkaline bases is diminished a third. That is to say, the free acidity of the urine, which represents a considerable portion of the acid salts passing into the blood from the decomposition of the food and tissues, as well as the neutral salts—the chlorides—are increased, whilst the alkaline phosphates are decreased.

2. *The pathological effect of the withdrawal of fresh vegetable food on the composition of the urine.*—The following table gives the amount of urine, the total urinary solids, the degree of acidity, the urea and the phosphoric acid, and the reputed normal and the observed weight of the patient when admitted, of four cases of scurvy under treatment at the Seamen's Hospital, in the spring of last year, from ship *Westridge*. The observations were made after the patients had been in the hospital nearly a week. All the cases were well-marked, though not very severe, instances of the disease, uncomplicated by other affections. Case 1 was the worst; whilst in

Case 4 the disease was very slight, and the patient was nearly convalescent at the time the observation was made.

TABLE III.*

*Showing the general character of the urine in scurvy.*

| | Age. | Normal weight. | Present weight. | Quantity of urine. | Total solids. | Urea. | $PO_4$ | Acidity. |
|---|---|---|---|---|---|---|---|---|
| Case 1 . . | 41 | 136 lb. | 110 lb. | 800 c.c. | 41 grms. | 27 grms. | 1·6 | 0·6 |
| Case 2 . . | 28 | 163 lb. | 145 lb. | 900 c.c. | 47 grms. | 18 grms. | 0·9 | 0·9 |
| Case 3 . . | 38 | 168 lb. | 143 lb. | 1500 c.c. | 38 grms. | 19 grms. | 1·5 | 0·7 |
| Case 4 . . | 38 | 175 lb. | 150 lb. | 1500 c.c. | 48 grms. | 36 grms. | 2·2 | † |

These observations agree closely with those made by others.† Budd and Simon have noticed, when the cases first come under observation, the urine is generally scanty and high coloured, but that under treatment it rapidly becomes more abundant and clearer. Charpentier has made the same observation. The change is due, I think, to the fact that in hospital the patients get a more abundant liquid diet than is possible for them to obtain outside its walls. The total solids are

* I am indebted for the analyses in this table to my friend Dr. H. Law, who was at that time house-physician at the Dreadnought, and who obligingly gave much of his time aiding me in this as in other inquiries in chemical pathology.

† Budd: *op. cit.* Simon: *Pathological Chemistry,* vol. ii., p. 258. Charpentier: *Etude sur le Scorbut en général, l'Epidemie de* 1871 *en particulier.* Chalvet: *Bulletins de la Soc. Méd. des Hôpitaux Compte Rendu.*

generally diminished, unless albuminuria is also present, when they are increased. The urea is much less than in normal urine in proportion to the weight of the body (Simon, Charpentier, Chalvet). The uric acid, according to Simon, is generally above the average. In the cases given in the above table the uric acid was not estimated quantitatively; it was, however, deposited spontaneously from the urine in each case in considerable quantities. In other cases, where I have determined the amount, the quantity has been in excess; in one case only have I met with it below the normal. The amount of the free acid passing out of the system is diminished; this agrees with the observation of Simon, who says, "the urine is slightly acid as it passes from the bladder." The fact that the acidity of the urine is diminished in scurvy would at first sight seem to tell against the hypothesis of diminished alkalinity of the blood. It should not be forgotten, however. that the acid reaction of urine is generally considered due to the decomposition that occurs between an acid or an acid salt and neutral phosphate of sodium in the blood, forming acid sodium phosphate, which passes out with the urine. Now, one of the chief acid salts in the blood is undoubtedly bicarbonate of potash or soda—an acid salt with

an alkaline reaction. The neutral phosphate has also an alkaline reaction. The decomposition which results between these two salts may be represented as follows :*—

| Bicarbonate. | | Neutral Phosphate. | | Carbonate. | | Acid Phosphate. |
|---|---|---|---|---|---|---|
| $NaH_2CO_3$ | + | $Na_2HPO_4$ | = | $Na_2HCO_3$ | + | $NaH_2PO_4$ |

In scurvy the amount of carbonic acid is diminished—(1) from the diminished metamorphosis of tissue going on in the body; (2) from the inability to take much food from weakness, and also soreness of gums; (3) the previous long continued withdrawal of organic vegetable acids, which, by oxidation, yield carbonic acid. The second cause likewise operates in diminishing the amount of neutral phosphate of soda received into blood.† If the two factors which are chiefly concerned in maintaining the alkalinity of the blood, and, by their decomposition, the acidity of the urine, are thus diminished, it is easy to see that the amount of free acid in the urine

* For experiment demonstrating this point, vide *The Lancet*, July, 1874, "Separation of Acid Secretions from the Alkaline Blood."

† This is especially the case when the disease is severe. In the early stages of the illness, however, it is probable that the alkaline phosphates are retained to maintain this alkalinity of the blood in conpensation for the withdrawal of the alkaline carbonates. For if this were not the case it would be difficult to explain how when vegetable food is cut off the

may be lessened as well as the alkalinity of the blood. I have found that with an improved dietary and restoration of strength the acidity of the urine invariably increases, and sometimes exceeds the normal for a time. No complete observations have as yet been made with regard to the variations of the inorganic constituents of the urine in scurvy. Garrod, as before remarked, has pointed out the diminution of potash in this disease. Heller* has noticed augmentation of ammonia and earthy phosphates and diminution of chloride of sodium. Martin,† in one analysis, has recorded that the soluble salts consisted for the most part of chloride of sodium.

In the following table I have given the results of three analyses of urine in a patient, showing the variations, chiefly of the more important constituents, occurring from admission to convalescence. Analysis I. represents the urinary constituents of the twenty-four hours' urine of a severe uncomplicated case of scurvy two days after admission into the Seamen's Hospital, the diet being two pints of

excretion of the alkaline phosphates is at once considerably diminished though the quantity ingested remains the same. Vide Table ii, vi and vii.

* Simon: *Pathological Chemistry*, vol. ii., p. 260.

† *Ibid.*

beef-tea, three pints of milk, two eggs, twelve ounces of bread, and four ounces of brandy; no medicine, lime-juice, or fresh vegetables being given. Analysis II.: the twenty-four hours' urine of the same patient, on the same diet, but with the addition of six ounces of Trommer liquid malt extract, an excellent antiscorbutic, and on which the patient improved considerably. Analysis III.: the twenty-four hours urine in same patient, after a fortnight of a dietary consisting of eight ounces of meat, twelve ounces of bread, four ounces of potatoes, eight ounces of lime-juice, and four ounces of cabbage; the gums at this time being still tender, and mastication imperfect.

TABLE IV.

*Showing variations of constituents of urine in a case of scurvy under treatment, from admission to convalescence.*

| | Analysis I. | Analysis II* | Analysis III. |
|---|---|---|---|
| Quantity | 1590 cc. | 970 cc. | 1100 cc. |
| Free acid | 0·64 grms. | 1·5 grms. | 1·6 grms. |
| Urea | 28·8 „ | 22·5 „ | 27·0 „ |
| Uric acid | 0·33 „ | 0·21 „ | 0·54 „ |
| Chlorine | 7·2 „ | 4·5 „ | 4·6 „ |
| Sulphuric acid | 1·6 „ | 2·1 „ | 2·3 „ |
| Phosphoric acid with lime and magnesia | 0·47 „ | 0·7 „ | 0·7 „ |
| Phosphoric acid with potash and soda | 0.76 „ | 1·5 „ | 1·6 „ |
| Potash | 1·81 „ | † | 1·24 „ |
| Soda | 4·11 „ | † | 1·45 „ |

* Diarrhœa on day of collection of urine. † Not estimated.

The important points to be noticed are the increased acidity of the urine on the administration of antiscorbutics, the diminution of the chlorides, the relative increase of potash, and the *large absolute* increase of the alkaline phosphates. In another case in the hospital at the same time a similar increase in the alkaline phosphates was noticed; the amounts being on admission 0·57 grms., and after eight days on antiscorbutic diet 1·6 grms. As the case was complicated with hemiplegia, probably due to syphilis, a complete analysis of his urine was not made.‡

3. *The inorganic constituents of scorbutic and antiscorbutic diets.*—In Table V. the daily rations of the English sailor at sea are contrasted with those of the soldier on home service, each being fair instances of scorbutic and antiscorbutic diets respectively, since there can be little doubt that with such a dietary the sailor, except for the occasional use of fresh vegetables when in port, or the protective influence of lime-juice when at sea, would speedily become scorbutic. Table VI. gives the alkalinity of the ash and the inorganic constituents

‡ I have to thank Dr. Murphy, our present house-physician at the Dreadnought, for the trouble he took with regard to the collection of the urines and recording fully the diets.

of the chief articles of food in each dietary in 100 parts: and in Table VII. I have given the total alkalinity and amount of inorganic salts ingested daily by the soldier and sailor respectively.

## Table V.

*Daily dietary of the English sailor and soldier.*

| Sailor at Sea.* | Ounces. | Soldier on Home Service.† | Ounces. |
|---|---|---|---|
| Salt meat | 16 | Meat | 12 |
| Biscuit or soft bread | 24 | Bread | 24 |
| Flour | 9 | Potatoes | 16 |
| Peas | 5 | Other vegetables | 8 |
| Currants and raisins | 1½ | Coffee | ⅓ |
| Chocolate | 1 | Tea | ⅛ |
| Tea | ¼ | Salt | ⅕ |
| Sugar | 2 | Sugar | 1⅓ |
| Suet | ¾ | Milk | 3⅕ |
| Total | 59½ | Total | 65¼ |

* Royal Navy Scale of Victualling, taken from report of Committee of the Society for Improving the Condition of Merchant Seamen, printed in 1867. Since then, however, a quarter of a pound of preserved potatoes, on alternate salt-beef days, or twice a week, has been added to this dietary.

† *Manual of Practical Hygiene*, by E. Parkes, M.D., F.R.S. Second Edition, p. 150.—1866.

## Table VI.

*The alkalinity of the ash and the inorganic constituents of the principal articles of food, in* 100 *parts.*

| —— | Fresh Meat. | Salt Beef. | Potatoes. | Peas. | Flour. |
|---|---|---|---|---|---|
| Alkalinity of the ash as Bicarbonate of Potash | 0·62 grm. | 0·56 grm. | 1·31 grm. | 1·12 grm. | 0·32 grm. |
| Phosphoric acid . . | ·58 grm. | ·42 grm. | ·19 grm. | ·35 grm. | ·45 grm. |
| Chlorine . . . | ·11 ,, | ·72 ,, | ·04 ,, | ·02 ,, | ·01 ,, |
| Sulphuric acid . . | ·07 ,, | ·03 ,, | ·05 ,, | ·06 ,, | ·01 ,, |
| Lime . . . . | ·06 ,, | ·03 ,, | ·02 ,, | ·06 ,, | ·03 ,, |
| Magnesia . . . | ·04 ,, | ·04 ,, | ·03 ,, | ·07 ,, | ·11 ,, |
| Potash . . . . | ·52 ,, | ·34 ,, | ·54 ,, | ·39 ,, | ·22 ,, |
| Soda . . . . | ·13 ,, | ·84 ,, | ·04 ,, | ·12 ,, | ·09 ,, |

## Table VII.

*Total alkalinity of the ash and the inorganic* constituents of the daily ration of the sailor and soldier.*

| | Sailor. | Soldier. |
|---|---|---|
| Alkalinity as Bicarbonate of Potash . | 5·9 grms. | 10·3 grms. |
| Phosphoric acid . . . . . | 5·49 grms. | 6·01 grms. |
| Chlorine† . . . . . | 3·61 ,, | ·64 ,, |
| Sulphuric acid‡ . . . . . | ·23 ,, | ·55 ,, |
| Lime . . . . . | ·34 ,, | ·51 ,, |
| Magnesia . . . . . | 1·11 ,, | 1·05 ,, |
| Potash . . . . . | 3·64 ,, | 5·69 ,, |
| Soda . . . . . | 4·59 ,, | 1·27 ,, |
| Total . . . . . | 19·01 ,, | 15·90 ,, |

The proportion of albuminates in both dietaries is about equal—perhaps, if anything, it is in favour of the soldier; for, though the sailor gets sixteen ounces of meat to twelve received by the soldier, allowance must be made for the weight of salt and the nutritious matter dissolved out into the brine. But the sailor's dietary is below that of the soldier in actual quantity, and this deficiency is caused by the withdrawal of no less than twenty-four ounces of succulent vegetable food, which is poorly replaced by nine ounces extra of flour, five ounces of split peas, and an ounce and a half of currants and raisins. The presence of a considerable amount of chloride of sodium from the salted provisions renders the total weight of the ash higher in the sailor's rations than in the soldier's, otherwise the inorganic constituents are less, notably the potash, whilst the alkalinity of the ash is considerably lower. This diminution of the alkalescence of the ash has no relation to the deficiency

* No deduction has been made for weight of bone, and the weight of bread and biscuit has been calculated as flour.

† The salt taken with the food is not calculated.

‡ The quantity of Sulphuric acid seems small, but it must be remembered that the sulphuric acid passing out of the system is chiefly derived from the oxidation of the sulphur of the albuminous substances in the body, and not so much from the sulphates taken with the food.

of potash, nor is it caused by the increase of the neutral salts, but is absolute, as can be shown by the fact that if sixteen ounces of fresh meat be given instead of sixteen ounces of salt, the alkalescence is only increased 0·2 grm., whilst the potash is increased 0·8 grm., the chlorine and soda being diminished 3·12 grms. and 3·18 grms. respectively.† The cause of the higher alkalescence of the ash of the soldier's rations can be understood by a reference to table VI., where it will be seen that there is ·76 part of phosphoric acid, chlorine, and sulphuric acid, to ·75 part of lime, magnesia, potash, and soda in 100 parts of fresh meat; whilst in 100 parts of potato there is only ·28 part of phosphoric acid, chlorine, and sulphuric acid, to ·63 part of lime, magnesia, potash, and soda, the alkaline bases being chiefly in combination with vegetable organic acids, and which by oxidation yield *alkaline carbonates*.

We will now proceed to the consideration whether the changes which occur in the blood and tissues in

† With sixteen ounces of fresh meat taken in place of sixteen ounces of salt, the sailor's ration would yield—alkalescence as bicarbonate of potash, 6·1; phosphoric acid 6·07; chlorine, ·49; sulphuric acid, ·47; lime, ·57; magnesia, 1·05; potash, 4·45; soda, 1·41; total, 14·51 grms.

scurvy are due to the withdrawal of some special constituent required directly for their nutrition, or are brought about by some chemical alteration in the quality of the blood, which interferes with the processes of nutrition. And here we pass from the domain of fact to the region of hypothesis, for we know as little of the part played by the inorganic substances in histogenesis as we do of the variations that daily and hourly occur in the chemical composition of normal blood, and we have yet to learn what action—physical as well as chemical—the inorganic constituent of each tissue has on the albumens, fats, salts, and water that compose that tissue, and how far excess or diminution of these constituents influences oxidation and nutrition going on in the textures. The chief argument which can be urged against the view that scurvy originates from a physical cause, as the withdrawal of some special constituent required for the nutrition of the blood and tissues, is that scurvy is not a disease brought on by mere reduction in the amount of food. A starving man subsisting on roots and berries will not have scurvy, whilst the most liberal allowance of meat will not prevent its occurrence if fresh vegetables are withheld; the amount, however, required of these is small, and

out of all proportion to the immense protective influence they afford. The argument that tells against the hypothesis that scurvy originates from the withdrawal of some constituent required for the histogenesis of the blood and tissues, supports the view that the disease is primarily brought about by some chemical alteration in the quality of the blood.

We have seen that in the urine of scurvy patients the following characters may be noted:—1st, increase of uric acid; 2nd, diminution of acidity of urine; 3rd, reduction of alkaline phosphates. And we have also seen that the same changes, with the exception that the acidity of the urine was increased, followed the withdrawal for a short time of vegetable food. The fact, however, that the *pathological effect* of the withdrawal of succulent vegetable food is to diminish, and the *physiological effect* to increase, the acidity of the urine is not contradictory, or opposed to the view that the alkalinity of the blood is diminished in both instances. As long as health is maintained, a considerable quantity of acid is formed in the system from metamorphosis of the food and tissues, and probably also, as Dr. Parkes‡

‡ Dr. Parkes's Observations on the Dietetic Treatment of Disease.—*The Lancet*, May 23rd, 1874.

has suggested, from decomposition of some of the chloride of sodium, which a nitrogenous diet prompts one to make use of in considerable quantities. When, however, the disease is induced the amount of acid derived from these sources is lessened, whilst the full effect of the withdrawal of the carbonic acid derived from the oxidation of the vegetable acid is fully felt. I have already (p. 12) explained how, by decomposition of two salts having an alkaline reaction—the acid carbonate and neutral phosphate of potash or soda—the acidity of the urine is produced, and why the free acidity of the urine may be lessened at the same time that the alkalinity of the blood is diminished. Indeed, it may be stated that the physiological effect of the withdrawal of fresh vegetable food is to diminish the alkalinity of the blood by increasing the acid salts (chiefly urates), and the pathological effect is to reduce the alkalinity by decreasing the salts having an alkaline reaction—viz., the acid carbonates. We have also seen that the alkalinity of the ash of a typical scorbutic diet is considerably less (more than four grammes of bicarbonate of potash) than the alkalinity of the ash of a typical antiscorbutic diet, and this diminution is nearly the same with fresh as with salt meat, and that the

higher alkalescence of the ash of the antiscorbutic ration was shown to be caused by excess of alkaline carbonates,§ derived from the oxidation of the vegetable organic acids in combination with the alkaline oxides. Now the reaction of the blood in the living body is always alkaline, and under no condition has it ever been observed to become acid. What the degree of alkalescence of normal blood is has not been determined, but it is probable that, like the temperature and specific gravity, it has certain definite limits which cannot be passed in either direction without causing disturbance of healthy

§ It may be urged that whilst I have stated that the alkaline phosphates of the urine are diminished in scurvy or by the withdrawal of fresh vegetable food (*vide* Tables I. and III.) such diminution cannot be accounted for by reference to the tables of diet. On the contrary, it will be seen from Table V. that one pound of meat yields more than double the amount of alkaline phosphates derived from a pound of potatoes. This apparent discrepancy, however, may be explained by the hypothesis that some portion of the alkaline phosphates is retained in the system to compensate in some degree for the withdrawal of the alkaline carbonates. This view is in accordance with experimental fact; for F. Hoffman, to ascertain the effect of acids on blood, fed pigeons with a food yielding an acid ash, and found that the body, under such circumstances, retained its alkaline salts with great obstinacy.

nutrition. Experiments made on animals to reduce the alkalinity of the blood, or to neutralize it, have all ended sooner or later in the death of the animal, and the changes observed in the blood and tissues after death are identical with those found in the bodies of patients dying from scurvy—namely, dissolution of the blood-globules, ecchymoses in the heart, with blood-stains in the mediastinum, gums, and mucous surfaces, whilst the muscular structure of the heart, the muscles generally, and the secreting cells of the liver and kidneys become granular and even distinctly fatty.* Exactly similar conditions have been observed in animals dying after having been fed for a considerable time on food yielding only an acid ash;† and not only did the post-mortem changes resemble those of scurvy, but the symptoms preceding death were exactly alike—namely, great feebleness, tremor, and failure of the heart's action, the blood at the time of death being still alkaline.

From a review of the above considerations and

* Leyden and Munk: Virchow's Archiv. xxii., 237; Die acute Phosphavertiftung. Berlin, 1865. Traube: Berliner Klinische Wochenschrift, Nos 9—15. 1894.

† F. Hoffman: Ueber der uebergang von frein säuren durch das alkalische Blut in den Harn; Zeitschrift für Biologie, vii., 338.

facts I venture to think we may draw the following inferences, if not conclusions:—

1. That the primary change that occurs in scurvy is *a chemical alteration* in the quality of the blood.

2. That this chemical alteration as far as can be judged from inferences drawn from the analysis of urine in patients suffering from scurvy, and analysis of "scorbutic" and "antiscorbutic" diets, points to a *diminution of the alkalinity of the blood*.

3. That this *diminution of alkalinity* is produced in the first instance (physiologically) by an increase of acid salts (chiefly urates) in the blood, and finally (pathologically) by the withdrawal of salts having an alkaline reaction (chiefly alkaline carbonates).

4. That this *diminution of the alkalinity* of the blood finally produces the same results in scurvy patients as happens in animals when attempts are made to reduce the alkalinity of the body (either by injecting acids into the blood or feeding with acid salts) namely, dissolution of the blood-corpuscles, ecchymoses, and blood-stains on mucous surfaces, and fatty degeneration of the muscles of the heart, the muscles generally, and the secreting cells of the liver and kidney.

*Queen Anne Street, W.*