ON

GRAVEL, CALCULUS, & GOUT:

CHIEFLY AN APPLICATION OF

PROFESSOR LIEBIG'S PHYSIOLOGY

TO THE

PREVENTION AND CURE OF THESE DISEASES.

BY

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"How important are these views, in reference to so common and so dangerous a disease (calculus), and how probable is it that a rational application of them may serve greatly to assist in its prevention, or even in its cure."—*Quarterly Review, No. CXXXIX.*

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THE

FOLLOWING APPLICATION OF THE PRINCIPLES

OF PROFESSOR LIEBIG'S PHYSIOLOGY

IS DEDICATED TO HIM

BY

HIS FRIEND AND PUPIL,

H. BENCE JONES.

PREFACE.

THESE pages owe their origin to the suggestion in the Quarterly Review. In writing them, I have assumed that the theories of Professor Liebig were probably true, because most of them seemed to me founded on facts which are well known, and to possess the evidence of simplicity in a high degree. I have tried to add something to that probability by shewing their application to gravel and gout.

In the Chapter on Gout, it will be seen how far practical experience at different times has sanctioned the conclusions to which these theories lead us.

In the Second Part, on Calculi, I have given Berzelius's remarks upon them as nearly as possible in the words of the German Edition of his Handbook, with some additions which appeared useful. I thought this would be more valuable than a statement of what had occurred to others, and to myself, in the examination of Calculi. With regard to their removal, I have dwelt only on that mode which is more particularly the province of the Chemist and the Physician; and by shewing the difficulties as well as the success of the treatment by solution, we may at some future time learn how the latter may be rendered more certain and the former be more easily overcome.

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ON

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ON

GRAVEL AND GOUT.

CHAPTER I.

ON THE URIC ACID DIATHESIS.

By the constant changes which take place in the body, some substances are produced which can be of no further use, and must therefore be removed. Of those which are thrown out, we may, speaking generally, say that acids, highly nitrogenised substances, and salts are carried off by the kidneys. In the state of health the excess of water in the body is thrown off with them, and is sufficient to retain them in solution, and a deposit takes place in the urine, only when the nitrogenised substances are produced in excess, as compared with the water, or when they do not undergo those changes which they usually do, or when the acids which effect the solution of the salts are wanting.

The deposit assumes different forms according to the substances of which it consists ; it may be either in the form of a fine powder, that is without definite form, or with a definite form in crystals or crystalline masses. Those substances which have no definite form, and which render the water thick, muddy, or milky, consist of urate of ammonia and phosphate of lime with phosphate of ammonia and magnesia.

Those which have a definite form, appearing as crystalline masses, or gravel, alone or mixed with the fine powdery deposit, consist of uric acid, oxalate of lime, and phosphate of ammonia and magnesia.

The deposit assumes different colours, according as it is mixed with different colouring matters; all the substances which form urinary concretions being perfectly white when they are obtained pure.

By the term uric acid diathesis is intended that state of the system which produces a constant deposit in the urine of uric acid, either free, or combined with some base. It is usually red, more rarely yellow, and most rarely white. It is entirely soluble in alkalies, and when it consists of the urate of ammonia, it is soluble by heat alone. The constancy of its occurrence indicates disease; for in the state of health such a deposit will occasionally take place.

With regard to the state in which the uric acid occurs in the urine, there is a difference of opinion between Dr. Prout and Berzelius; first, with regard to the frequency and to the form of urate of ammonia; and, secondly, with regard to the nature of the substance with which it is occasionally coloured. Dr. Prout believes that the urate of ammonia exists as such always in the urine; and that it forms an amorphous sediment, which is occasionally tinged with different shades of pink in consequence of the formation of purpurate of ammonia, which is produced by the action of nitric on uric acid.

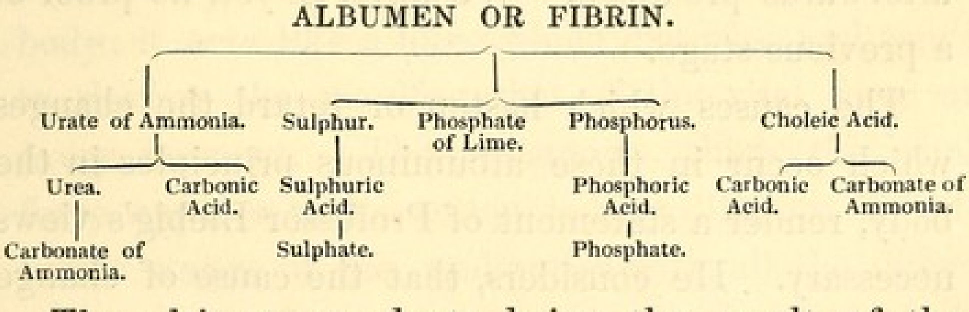
Whilst Berzelius thinks that the urate of ammonia is not generally present; that when it is so, it forms, when crystallized, large angular crystals; and that usually uric acid exists in the urine, which has some peculiar power of holding it in solution: and he also thinks the occasional colour does not arise from purpurate of ammonia, but from some modification of the ordinary colouring matter. As these questions have been much disputed, I will give Berzelius's words in an appendix.

With regard to the colour, I think the arguments of Berzelius are very sufficient; but on the other question, during the last five years in which I have constantly examined such sediments in St. George's Hospital, I have much more frequently found that the red sediment is redissolved by heat alone, than Berzelius appears to have found it. At any rate, a sediment soluble by heat alone is that which most frequently occurs in London; it is more rarely that the sediment is met with which is soluble in alkalies but not by heat alone; and the statement of Berzelius, that the more distinctly crystals can be recognized, the more impurity there is from bases, does not at all agree with the observations I have made with the microscope, using a high power, nor with the microscopic drawings given by Dr. Prout of uric acid and urate of ammonia, nor with those of Dr. G. Bird in the Guy's Hospital Reports for April, 1842, in which there is a statement, that uric acid crystallizes in eight different forms. This must lead to the supposition that uric acid alone was not examined, but also some combinations of it with other substances, which have not been distinguished.

CHAPTER II.

ON THE PRODUCTION OF URIC ACID FROM THE ALBUMINOUS TISSUES.

By the albuminous tissues are to be understood those, which consist of a substance, which when analyzed shews that it contains nearly the same elements in an hundred parts as albumen does; or in other words, which can be represented by nearly the same formula as the albumen of the blood, or white of egg: these tissues, like albumen or fibrin, consist of protein combined with sulphur, phosphorus, and phosphate of lime, and like these, they may undergo metamorphosis; thus, the muscular tissues may be supposed in the living body to divide into other substances, as albumen or fibrin might do.



The ultimate products being the result of the action of oxygen on those substances which were first produced.

Now this diagram may be also taken to represent the production of the urate of ammonia from the albuminous tissues, and in it the second or lower products shew the substances which may appear in the secretions when oxygen can act on the first products; the urea, sulphuric acid, and phosphoric acid being thrown out by the kidneys, and the carbonic acid by the lungs.

We can have no idea of life continuing without perpetual change, which is evident from the never-ceasing muscular action, respiration, secretion, and absorption. The constant production of uric acid is a consequence of these changes. The albuminous tissues gradually divide into different substances, some useful, others useless, and these last are removed from the body, though for their more easy removal they may, as in the case of uric acid, undergo further changes. At present we must consider the uric acid as arising directly from the albuminous tissues, that is, without any other substance being previously formed, from which the uric acid is afterwards produced. We have, as yet, no proof of a previous stage.

The causes which hasten or retard the changes which occur in these albuminous principles in the body, render a statement of Professor Liebig's views necessary. He considers, that the cause of change in the albuminous substances is the chemical action of oxygen, which takes place only when the resistance which the vital force of living parts opposes to this chemical action is weaker than that chemical action itself.

This vital power requires for its manifestation a high temperature, and is diminished by muscular motion, p. 243; so that in equal times, and temperatures, the amount of change in the albuminous tissues may be taken to be directly proportional to the amount of muscular action, p. 245; and in equal times, with equal muscular action, if we surround a part of the body with ice or snow, there occurs more or less quickly, in consequence of the loss of heat, an accelerated change of matter, p. 252. We may indirectly promote change by hastening the formation of the ultimate products from these tissues. This may be done by increasing the action of the oxygen, by increasing the blood globules, and by abstaining from non-azotised food, also by giving alkali to promote the formation of bile (or choleic acid), and by giving an excess of albuminous food, which may supply the waste of the tissues, p. 259. The oxygen of the atmosphere is the proper active external cause of the waste of matter in the animal body; it acts like a force which disturbs, and tends to destroy the manifestation of the vital force at every moment. The resistance which the vital force opposes to its action is very different in different stages of life, and varies with all the different states and circumstances in which the body is placed; and when the opposition ceases, the phenomena of death appear when the oxygen combines with all the tissues of the body according to the affinity which it has for the different substances of which they consist.

These are the views of Professor Liebig, from which it follows that the less resistance the vital power makes to the action of oxygen, the greater will be the amount of change, and the more uric acid will be produced in the albuminous tissues; and the resistance being diminished by muscular action, and low temperature, these will also produce an excess of uric acid. By overcoming the resistance by increasing the amount of oxygen, the same effect will be produced. So that much oxygen, a low temperature, and much muscular exertion may be looked on as the causes of an excessive production of uric acid from the albuminous tissues.

From this it follows, if the uric acid underwent no change, but appeared in the urine in the same quantity as it was formed in the albuminous tissues, that our object would be to increase the resistance of the vital principle, and to lessen the action of oxygen; but though in the treatment of the uric acid diathesis it is of primary importance to increase the resistance of the tissues to the action of oxygen by avoiding all that tends to reduce the vital powers, and by tonics, and sometimes even by stimulants; yet it will be shewn to be even more important to promote further changes in those substances which arise from the tissues, that is, to effect a change in the uric and choleic acids; and that a deposit containing uric acid can rarely occur as a consequence of excessive changes taking place in the albuminous tissues, for whenever there are very rapid changes a large quantity of oxygen will usually be absorbed, which will effect a further change on the uric acid, which results from the action on the tissues; and the metamorphosis of the uric acid will be more ready and complete, the greater the quantity of oxygen present.

If oxygen be in excess, uric acid will no longer appear in the urine, but urea will be formed in large quantities. We have an actual proof that no uric acid appears in the urine when there is excessive change of the tissues in carnivorous animals which live on albuminous principles alone, and absorb much oxygen, and whose urine yet contains no uric acid; although in these, as Professor Liebig has pointed out, the changes in the tissues, in order to support the function of respiration, must be far more rapid and extensive than in man or in graminivorous animals. So that in carnivorous animals, though the greatest quantity of uric acid must be supposed to be produced in the albuminous tissues, yet, in consequence of the changes which it undergoes, by means of the excess of oxygen in the system, none of it appears in the urine.

This is far otherwise in those carnivorous animals which take in little oxygen, or in which the oxygen is prevented acting on the uric acid in consequence of an excess of non-nitrogenous food being eaten.

This is seen in the boa constrictor, which makes use of scarcely any voluntary muscular action, and is kept in a warm atmosphere; a considerable quantity of uric acid is produced by the changes in the tissues, whilst in consequence of the small quantity of oxygen which is absorbed, no further change takes place, and all the uric acid appears as urate of ammonia in the urine. Some urate of ammonia, under almost all circumstances, appears in the urine of man, in consequence of the quantity of non-nitrogenous substances in his food, and the supply of fat which exists more or less in all renders it almost impossible for that excessive action of oxygen to take place, by which all the uric acid is changed into urea, excepting indeed in some diseases, as scurvy, or phthisis; though perhaps from the great vascularity of the muscular tissues, it may be supposed that all the uric acid which arises from their metamorphosis becomes changed into urea, and so possibly none of the uric acid which appears in the urine may be derived from this source; or perhaps only when the blood is excessively loaded with non-nitrogenous principles on which the oxygen acts more readily (from the vital power offering less resistance) than it does on the tissues of the body or on the highly nitrogenised uric acid: indeed, whilst the non-nitrogenous principles exist in the blood in excess and undergo those changes which render them fit for the process of respiration, no excessive action of oxygen on the albuminous tissues can take place.

Thus Professor Liebig considers that alcohol may hinder the changes in the tissues of the body; and muscular exertion has been used as a means of cure in that state of system which arises from the excessive use of alcohol. Whilst then an excess of the non-nitrogenous principles exist in the blood, if a large amount of oxygen be absorbed this will not cause a rapid change in the tissues, nor thus give rise to an excess of uric acid. And usually, when an excess of oxygen is present in the blood, before it acts on the tissues it would first effect changes in the uric acid, so that though the urine would have a higher specific gravity than usual, and an excess of urea would exist in it, still no deposit of uric acid would take place, it having all undergone a further change from the action of oxygen. This is seen in phthisis,* which disease Professor Liebig

* This view of some connection between phthisis and excessive action of oxygen was published by Dr. Beddoes in 1793. He says, "Is there not an excess of oxygen in the system of consumptive persons?" May not pregnancy retard consumption in consequence of the fœtal aeration depriving the general system of some oxygen? The clearness of skin in persons disposed to phthisis is a general observation. Fourcroy tried the inhalation of oxygen in twenty patients, who became much worse, whilst Priestly mentions some cases in which great benefit was derived from inhalation of carbonic acid. These form Dr. Beddoes's chief arguments; to which might be added the usual disappearance of all fat; the state of the appetite, the activity of the brain, the benefit derived from a milk diet, from cetaceum, from the popular remedy of lard and milk, from Iceland moss, and karrigeen.

thinks is induced by an excessive action of oxygen on the different tissues of the body, and in phthisical patients, a deposit of uric acid or urate of ammonia is very rare, probably in consequence of the excess of oxygen acting on the uric acid before it attacks the tissues. So that although the uric acid is formed from the albuminous tissues, and in greater quantity when the amount of action of the oxygen is greatest, still then the uric acid itself will also be acted on by the oxygen, and no deposit of this substance will appear in the urine.

The injury which results from any lowering cause, as excessive mental or bodily exercise, from a course of mercury, from insufficient food; all direct us to some relation between phthisis and the excessive action of oxygen. A want of power to render the non-nitrogenous substances which are taken as food serviceable for respiration may at some future time be found to be a cause of this disease.

CHAPTER III.

ON THE PRODUCTION OF URIC ACID FROM THE GELATINOUS TISSUES.

Professor Liebig states, that the changes which these undergo must be at their surface only. This cannot apply to the skin, though it does to other membranous tissues, to which a smaller quantity of oxygen is taken; and in these it must be expected that the changes should proceed more slowly, than in the more highly vascular tissues; and if anywhere the uric acid after its production underwent no further change, we should expect it to be in these tissues in which but little blood circulates, whenever the small quantity of oxygen which they receive happened to be lessened. Now it is in the cellular tissue around the joints, in the cartilages of the joints themselves, and more rarely in the substance of the skin, or thrown out as a powder on its surface, that urate of soda has actually been found.

This is actual demonstration of uric acid, formed by the changes which take place in these tissues. It does not occur always, because usually there is sufficient oxygen to change it into a more soluble substance, and thus to enable it to be removed; but when from long continued excess, and from little exercise, the oxygen does not act, then the urate of soda remains as a deposit.

The gelatinous tissues differ so much in the composition of 100 parts from the albuminous or fibrinous tissues, that it is impossible that they can be changed into the same constituent substances. But the composition of chondrine differs only from that of albumen, in containing more oxygen. So that in certain states of the system at least, it may be supposed that cartilage and albumen undergo the same changes.

The formula which Professor Liebig gives as corresponding most nearly to the analysis of gelatine is, $C_{32}N_5H_{27}O_{12}$, deducting from this one equivalent of urate of ammonia $C_{10}N_5H_7O_6$, there remains $C_{22}H_{20}O_6$. But the formula for fat is $C_{22}H_{20}O_2$.

So that we may suppose that gelatine, by giving up four atoms of oxygen, might be converted into urate of ammonia and fat; this may be represented thus:—

$$\begin{array}{lll} \text{Gelatine} = C_{32}N_5H_{27}O_{12} \\ -4\ \text{Oxygen} = \quad -O_4 \end{array}\Big\} = \Big\{ \begin{array}{l} C_{10}N_5H_7O_6 = \text{Urate of Amm.} \\ C_{22}\ H_{20}O_2 = \text{Fat.} \end{array}$$

$$\overline{C_{32}N_5H_{27}O_8} \qquad \overline{C_{32}N_5H_{27}O_8}$$

or

GELATINE.

Urate of Ammonia. Oxygen. Fat.

A similar result to the above is obtained by taking the formula $C_{48}H_{41}N_{7\frac{1}{2}}O_{18}$. In which the carbon is taken at 48 instead of at 32 as in the first formula.

The formula for chondrine differs from that for albumen or fibrin, only in containing more oxygen, if we omit the exceedingly small quantities of phosphorus and sulphur; and therefore, if a part of its oxygen be separated from chondrine, we may suppose it to be capable of change into choleic acid, and urate of ammonia, thus:—

$$\left.\begin{array}{ll}\text{Chondrine} = & C_{48}H_{40}N_6O_{20} \\ -3\ \text{Oxygen} = & -O_3\end{array}\right\} = \left\{\begin{array}{l} C_{10}H_7\,N_5O_6 = \text{Urate of Amm.} \\ C_{38}H_{33}N\,O_{11} = \tfrac{1}{2}\ \text{Choleic acid.}\end{array}\right.$$

$$C_{48}H_{40}N_6O_{17} \qquad C_{48}H_{40}N_6O_{17}$$

or by diagram, thus:—

CHONDRINE.

Urate of Ammonia. Oxygen. Choleic acid.

Whether this metamorphosis and giving off of oxygen from the gelatinous and cartilaginous tissues, always takes place in this way when the body is in the state of health, is not known; but it is known for certain, that the uric acid is actually found in those who are gouty, in whom there is a want of oxygen to effect the changes which are required; and that the gelatinous and cartilaginous tissues in these circumstances should part with the oxygen, and thus give rise to these products, is in the highest degree probable. Perhaps in the state of health the following diagram may represent the changes in the gelatine.

Gelatine	$= C_{32}N_5H_{27}O_{12}$	=	$C_{22}\ H_{20}O_2$	= Fat.
4 Water	$= H_4O_4$		$N\ H_3$	= Ammonia.
			$C_4\ N_4H_8\ O_4$	= 2 Urea.
2 Oxygen	$= O_2$		$C_6\ O_{12}$	= 6 Carbonic acid.
	$C_{32}N_5H_{31}O_{18}$		$C_{32}N_5H_{31}O_{18}$	

That is, gelatine, with the addition of four equivalents of water and two of oxygen, may be converted into fat, ammonia, urea, and carbonic acid; and the occurrence of fat in the cellular tissue may perhaps be regarded as rendering this view more probable. The chondrine, also containing more oxygen than albumen, would require less oxygen, in order to undergo the same metamorphosis as the albumen does when it obtains a larger supply of oxygen. We arrive then at the conclusion, that at least, whenever an insufficient quantity of oxygen is present, uric acid may be produced by the metamorphosis of the gelatinous tissues.

CHAPTER IV.

ON THE CHANGE WHICH THE URIC ACID UNDERGOES AFTER ITS FORMATION.

It has been shewn, that uric acid may be produced from the gelatinous, as well as from the albuminous, tissues; that from the changes which take place in the tissues, uric acid may be formed. If it were possible for all the uric acid which is formed to be excreted without undergoing any further change before it is thrown out, then the amount of change in all the tissues might be indicated by the amount of uric acid thrown out of the body, and we could only lessen the quantity of uric acid which might be excreted, by hindering the changes which take place in the tissues; and thus only could we prevent the uric acid diathesis. But the uric acid being a substance extremely complicated, by the action of oxygen and heat, readily undergoes changes, by which it is converted into substances of comparatively great solubility, which are consequently with much greater ease removed from the body.

Professor Liebig shortly states some of the changes which uric acid may be made to undergo out of the body, thus: "When uric acid is subjected to the action of oxygen, it is first resolved, as is well known, into alloxan and urea; a new supply of oxygen acting on the alloxan, causes it to resolve itself either into oxalic acid and urea, or into oxaluric and parabanic acids, or into carbonic acid and urea. This may be represented by the following diagram.

$$\left.\begin{array}{ll}\text{Uric acid} = & C_{10}N_4H_4O_6 \\ \text{4 water} = & H_4O^4 \\ \text{2 oxygen} = & O^2\end{array}\right\} = \left\{\begin{array}{l} C_8N_2H_4O_{10} = \text{alloxan} \\ C_2N_2H_4O_2 = \text{urea}\end{array}\right.$$

$$C_{10}N_4H_8O_{12} \qquad C_{10}N_4H_8O_{12}$$

which equal

$$\left.\begin{array}{l} C_2N_2H_4O_2 = \text{urea} \\ C_6 \quad O_8 = C_6O_8 \\ C_2N_2H_4O_2 = \text{urea}\end{array}\right\} = \begin{array}{l}\text{2 eq. urea} \\ + C_6O_8\end{array}$$

$$C_{10}N_4H_8O_{12}$$

$$\text{But } C_6O_8 + O = 3\,(C_2O_3) = \text{3 oxalic acid,}$$

$$\text{and } C_6O_8 + O_4 = 6\,(CO_2) = \text{6 carbonic acid.}$$

From this it is seen, that if four equivalents of water and three equivalents of oxygen are added to uric acid, it may ultimately divide into urea and oxalic acid; and if four equivalents of water and six of oxygen are added, it may divide into urea and carbonic acid. So that if a full quantity of oxygen is given to the uric acid, carbonic acid and urea may be obtained; if a smaller quantity, oxalic acid and urea; and if none is given, the acid remains unchanged.

Such changes can be effected in the laboratory, by submitting uric acid to heat, oxygen, and water; and it is by these three agents that similar changes are effected in the body. Even long exposure of impure urate of ammonia to the action of the oxygen of the atmosphere seems to effect a change of the uric into oxalic acid. Thus guano, the excrement of sea birds, when in a fresh state, was examined by Dr. Fownes, and it contained oxalate of ammonia with a trace of carbonate, undecomposed uric acid, brown organic matter, and water: a second quantity was examined also, and found to contain oxalate of ammonia with a little carbonate, organic matter, and water. It contained no uric acid. "The last specimen," says Dr. Fownes, p. 37 of the Proceedings of the Chemical Society, May 17th, 1842, "is evidently older and in a more advanced state of decomposition than the other. The presence of a large quantity of oxalate of ammonia is a curious fact, and was early noticed. There can be no doubt that this substance owes its existence, in some way or other, to the uric acid contained in the excrement of the sea birds. We can easily imagine that in this mass of putrefying substance, kept in a moistened state by the dews of night, a decomposition of a peculiar kind may be set up in the uric acid, and its gradual conversion into new products, among which may easily be oxalate of ammonia, effected perhaps somewhat after the following fashion:—

$$\left.\begin{array}{lll} \text{Uric acid} = & C_5H_2N_2O_3 \\ \text{4 eq. water} = & H_4\ \ O_4 \\ \text{1 eq. oxy.} = & O \end{array}\right\} = \left\{\begin{array}{lll} C_4 & O_6 & = \text{2 eq. oxalic acid.} \\ H_6N_2 & & = \text{2 ammonia.} \\ C & O_2 & = \text{1 carbonic acid.} \end{array}\right.$$

$$C_5H_6N_2O_8 \qquad C_5H_6N_2O_8$$

This view, it must be remembered, is merely hypothetical; but it is borne out by the facts." The oxygen is by far the most important agent in these changes; and we owe much to Professor Liebig for redirecting attention to it. He has shewn, that the quantity inspired varies with the temperature, dryness, and density of the air; and that it is carried to all parts of the body is rendered certain by the experiments of Magnus.

Professor Liebig has also shewn, that the waste of matter and the production of animal heat are both dependent on the absorption of oxygen. The water is both necessary to furnish its elements for the production of alloxan and urea, and also to keep those substances which are formed in such a state as may enable the oxygen to act on them most readily, whilst the heat renders the chemical changes more rapid and more complete. In the state of health, it would seem that these agents are in such quantities as to be sufficient to change the greater part, or even all the uric acid; but in general only the greater portion has undergone these changes, as a small quantity of uric acid, compared with the quantity of urea, is obtained from human urine. But at other times these agents may not be in sufficient quantity, and this applies chiefly to the oxygen, because it is scarcely possible for water to be deficient in any organic body; and as regards heat, we find it to be nearly constant in man under all ordinary circumstances. So that when there is a want of change in the uric acid, it may in almost every case be taken as the sign of a deficiency of oxygen; and this may be regarded generally as the cause of the uric acid diathesis; though if ever the quantity of water is insufficient to keep the uric acid in solution, the quantity of deposit will increase.

We are now able to see on what the quantity of uric acid which is actually thrown out of the body depends; for it is not possible for the uric acid to vary, excepting,

1st. With the quantity produced in the body.

2ndly. With the quantity changed before it is thrown out.

And supposing none to be changed, or the quantity changed to be constantly the same, then the quantity thrown out by the urine will vary directly as the quantity produced by the metamorphosis of the tissues. If, on the contrary, we suppose the quantity produced to be constantly the same, then the quantity thrown out will vary inversely as the quantity which undergoes a change in the body; because the more uric acid that is changed, the less will remain to be thrown out.

I have endeavoured to shew, that if ever there should be an excessive production of uric acid in consequence of a rapid change in the tissues, resulting from an excessive quantity of oxygen, then, when the oxygen is in excess, the whole of the uric acid which is produced will be acted on and changed, as has been shewn, into urea and carbonic acid; and, therefore, no deposit will appear in the urine when an excessive quantity of uric acid is produced, by means of an increased action of the oxygen on the tissues; so that we have generally to consider only the quantity which is changed in the body, as influencing the quantity of uric acid in the urine; and this general law may be thus stated: the quantity of uric acid which is thrown out of the body varies inversely with the quantity which undergoes a change in the body.

On looking to the agents which effect this change, it is seen, that oxygen is the most absolutely necessary, and that the other agents, the heat, water, and alkali, are chiefly useful, inasmuch as they enable and promote the action of the oxygen on the uric acid in the body. Thence it may be concluded, that the quantity of uric acid which is thrown out varies inversely with the amount of action of the oxygen; and thus the problem of the cure of the uric acid diathesis depends, tonics being excepted, on the question, how the uric acid in the body can be most acted on by oxygen, how it can be changed into urea and carbonic acid. It appears that this may be done—

1st. By giving a large supply of oxygen,
as by exercise,
by cold air,
and by medicine, as nitrous oxide water and iron.

2ndly. By diminishing the quantity of other substances, on which the oxygen acts more readily than on the uric acid; that is, substances consisting of hydrogen, carbon, and oxygen only:
as by abstaining from these as food,
by removing them by aperients,
and by sudorifics.

3rdly. By keeping all the uric acid which is produced in solution,
by water,
and by alkalies.

I shall say a few words on each of these points, quoting such parts of Professor Liebig's book as I think sufficient; but I would refer the reader to the book itself, which will repay the study which may be given to it. And, 1st. An increased amount of oxygen may be taken into the body by exercise, because "the consumption of oxygen in equal times may be represented by the number of respirations," and "the number of respirations is smaller in a state of rest than during exercise or work." So that the amount of oxygen which is absorbed is least when sleeping, and greatest on exertion. The same may be effected in a smaller degree by cold air; "for air is expanded by heat and contracted by cold, and, therefore, equal volumes of hot and cold air contain unequal weights of oxygen."

It is in the highest degree probable that the amount of oxygen may be increased by means of nitrous oxide. Professor Graham states, that when in solution, it possesses none of those stimulating properties which it exercises when absorbed as a gas.

By Professor Liebig's theory of respiration, the red globules are the carriers of oxygen, and the number of these may be increased by some preparations of iron. Hence it may be supposed, that iron may occasionally be an agent in increasing the amount of oxygen which is taken to the capillaries, and thus a part of the great benefit which is sometimes derived from such tonics in the uric acid diathesis must be explained; though more may perhaps be gained by these medicines rendering the vital powers more capable of resisting the action of the oxygen on the tissues of the body.

2ndly. The action of oxygen on the uric acid may be increased by lessening the compounds of hydrogen, carbon, and oxygen in the body; and this may be done by abstaining as much as possible from that food which Professor Liebig calls non-nitrogenised, or, the "elements of respiration." These substances serving for the support of the animal heat combine with oxygen readily; and thus, when existing in considerable quantities in the body, they hinder the action of the oxygen on the uric acid, which would otherwise be changed into urea and carbonic acid. So that when these principles exist in the body in great quantity, the uric acid does not undergo any change. These principles in Liebig's table are,

Fat,	Sugar of milk,
Starch,	Pectine,
Gum,	Bassorine,
Cane sugar,	Wine,
Grape sugar,	Beer.

Those which are liquid, or are capable of being dissolved, as gum, sugar, pectine, wine, and beer, as soon as they are taken into the stomach, are absorbed by the veins; whilst those which are insoluble, as the starch and fat, must become dissolved before they can be taken in; and this is effected in the starch, by its being changed into sugar and absorbed by the veins; and in the fat, probably by its combining with an alkali from the bile, and being carried in by the lacteals.

The starch forms a very considerable part of our food. It begins to change into sugar when it is taken into the stomach, and by degrees the whole is rendered soluble. The time this occupies varies with the state of the stomach (the mucus of which is the catalitic agent which effects this change), and with the quantity of starch. Usually it continues only a few hours after a full meal, and therefore, during this time, the quantity in the blood is larger than at other times. Hence probably it is, that there is then less action on the uric acid, and we consequently find the greatest deposit of uric acid, or the urates, takes place after a large meal, and continues for some hours. The oxygen may act on the sugar and fat, and convert them into carbonic acid and water, or these substances may first undergo some further change before they combine with the oxygen.

Professor Liebig seems to think that this is the case in graminivorous animals, and that the liver is the organ by which it is effected. Perhaps more accurate observation of that disease in which the sugar, from some cause not undergoing any change, is thrown out unoxydised in the urine,* and of that somewhat analogous disease which produces the cystic oxide calculus, in which frequently fat appears in the urine, and a large quantity of sulphur, carbon, and hydrogen passes off uncombined with oxygen, may hereafter throw some light on this point. How many substances exist in an unoxydised state in the cystic oxide calculus, may be seen from the following hypothesis of its composition.

* And it is worth observing, that many have considered this to be a disease of the liver; Dr. Willis says (Urinary Diseases, p. 220): "The bile would seem to have been remarkably implicated in every case, for this fluid, when particularly examined, has always been found to possess acid instead of its natural alkaline re-action, and to be of a very pale yellowish colour, and peculiarly fluid."

4 Atoms of cystic oxide $= 4\ (C_6\,N\,H_6\,O_4\,S_2)$
which equal

$$C_{10}\,N_4\,H_4\,O_6 = 1 \text{ atom uric acid.}$$
$$H_8\ \ S_8 = 8 \text{ atoms sulphuretted hydrogen.}$$
$$C_2\ \ H_2 = 2 \text{ atoms carburetted hydrogen.}$$
$$C_{12}\ \ H_{10}O_{10} = 2 \text{ atoms lactic acid.}$$

$$C_{24}N_4\,H_{24}O_{16}S_8 = 4\ (C_6N\,H_6\,O_4S_2)$$

These substances require no less than 68 equivalents of oxygen to convert them into such as are formed in the healthy state: that is, 32 equivalents of oxygen to change the sulphuretted hydrogen into sulphuric acid and water; 6 equivalents to convert the carburetted hydrogen into carbonic acid and water; 24 equivalents combining with lactic acid to form carbonic acid and water; and 6 equivalents of oxygen and 4 equivalents of water being required for the conversion of the uric acid into urea and carbonic acid.

The next means which we possess for increasing the action of oxygen, is by diminishing the quantity of those substances on which the oxygen acts, by aperients, and particularly by those medicines which produce a secretion and evacuation of bile. The bile may be looked upon as consisting of highly carbonaceous substances, which Professor Liebig considers to be re-absorbed into the system; these, when acted on by oxygen, he supposes partly to give rise to the animal heat. Other physiologists look on the excretion of bile as supplementary to the excretion of carbonic acid by the lungs; thus Carpenter's

Physiology, p. 425 : " By the liver the carbon is excreted in the form of a fluid, whilst by the lungs it is thrown off in a gaseous form."

There is a very evident connection between the amount of bile removed from the system, and the amount of uric acid in the urine. Thus we find in serpents, and some birds, which appear to throw out a very small quantity of bile, the urine which they pass consists almost entirely of urate of ammonia ; and we find in diseases of the liver, where little bile is thrown out, a large quantity of urate of ammonia is deposited in the urine.

In rheumatism and gout, we find those medicines which act on the liver greatly lessen the deposit of urate of ammonia. In one case of deposit connected with disease of the liver, the urine became clear with each purgative dose of calomel: authorities might be multiplied on this point. Galen says, " Those are to be purged whose urine contains gravel or a sediment."

Whether we agree with Professor Liebig, in thinking that these medicines remove the carbonaceous substances from the bowels before they can be reabsorbed, or believe with others, that our medicines merely increase the quantity secreted and carried out, makes no difference in the fact, that by purgatives we lessen the quantity of carbon in the blood, and thus we permit a freer action of oxygen on the uric acid.

Those emetics which produce bilious vomiting act in exactly the same manner. We may also diminish the quantity of non-nitrogenous compounds in the blood by sudorifics. For the perspiration contains probably both lactates and acetates, substances which are compounds of carbon, hydrogen, and oxygen;—for acetic acid $= C\ H_5\, O_3$, and lactic acid $= C_6\, H_5\, O_5$; the first, therefore, requiring ten equivalents of oxygen, and the latter twelve, to be converted into carbonic acid and water. By sudorifics these lactates and acetates are removed, undecomposed, from the blood, and thus the oxygen which would have been necessary to change them into carbonates is left to act on the uric acid. The great benefit which is occasionally experienced from sudorific medicines is not thus, perhaps, sufficiently accounted for, because the quantity of these substances which can be removed by perspiration cannot be supposed to be very great.

Perhaps we may hereafter find reason to believe with Liebig, that oxygen actually diffuses itself through the skin into the blood, in the same way and at the same time that the carbonic acid diffuses itself through the skin into the air; and this excretion of carbonic acid would be greatly increased when the membrane is moist, on account of the solubility of that gas in water.

This view of the absorption of oxygen by the skin is not new. I find it in an Essay on Bathing, by Sir A. Clarke, 1820, in a note, p. 101: "Some writers and practitioners are of opinion, that the cutaneous vessels, particularly of those parts of the body which are exposed to the air, absorb oxygen from the atmosphere, which causes, in some constitutions, eruptions of the skin."

But this diffusion of oxygen through the skin is as yet by no means generally allowed to exist, although in Henry's Chemistry, Vol. II. p. 358, it is said, "If the hand be confined in a portion of atmospherical air or oxygen gas, it has been ascertained that the oxygen disappears, and is replaced by a portion of carbonic acid."

3rdly. The uric acid may be acted on in an increased degree, by keeping it in solution; and this must be done from the time of its production in the ultimate tissues. We must distinguish between that good which the water effects by holding the uric acid in solution in the capillaries of the body, and that apparent good which is effected by holding the urate of ammonia in solution in the urine, and thus occasionally preventing those deposits which errors of diet might occasion. Some might think this sufficient, but in speaking of stone it will be shewn, that it is not only of great consequence to prevent sediment, but even to remove, if possible, any excess from solution, inasmuch as a solution which is nearly saturated with urate of ammonia will give a deposit as soon as any nucleus is formed. That the action of oxygen on substances in solution is much greater than on solid substances, is a consequence of the far larger surface and much greater closeness of contact, into which the particles can be brought when in solution; and the insolubility of uric acid in any dilute fluid, except alkaline water, renders it the only liquid which can be used.

It is in the use of some medicines which act as alkalies that the most decisive proof of the power of the oxygen to combine with non-nitrogenous substances in the blood is seen. Thus we give by the mouth, cream of tartar $= C_8\,H_4\,O_{10} + KO + HO$, it passes through the blood, and we find in the urine $C_8\,O_{16} + K\,O + H_5\,O_5$; that is, it has been changed into carbonate of potash and water, which could only take place by its combining with 10 equivalents of oxygen which have been inspired; for it will hereafter be shewn, that the same change takes place when a solution of this substance is absorbed by the skin; thus shewing that the change does not take place in the stomach. Sulphuret of potassium also, when given by the mouth, was found in the urine by Woehler in the form of sulphate of potash. We may even, perhaps, consider the change of benzoic acid into hippuric acid as a process of oxidation; for benzoic acid with urea and oxygen contains the elements of hippuric acid, carbonic acid and water. Thus—

$$\left.\begin{array}{ll} \text{2 Benzoic acid} & = C_{56}\;H_{20}O_{12} \\ \text{Urea} & = C_2\,N_2\,H_4\,O_2 \\ \text{48 Oxygen} & = \qquad\quad O_{48} \end{array}\right\} = \left\{\begin{array}{ll} C_{36}N_2\,H_{16}O_{10} & = \text{2 Hipp. acid.} \\ C_{22}\qquad\quad O_{44} & = \text{22 Carb. acid.} \\ \qquad H_8\,O_8 & = \text{8 Water.} \end{array}\right.$$

$$\overline{C_{58}N_2\,H_{24}O_{62}} \qquad \overline{C_{58}N_2\,H_{24}O_{62}}$$

or if we suppose the benzoic acid to combine with ammonia and oxygen thus—

$$
\left.\begin{array}{lcl}
\text{Benzoic acid} & = & C_{28}\ H_{10}O_{6} \\
\text{Ammonia} & = & N\ H_{3} \\
\text{24 Oxygen} & = & O_{24}
\end{array}\right\} = \left\{\begin{array}{lcl}
C_{18}N\ H_{8}\ O_{5} & = & \text{Hippur. acid.} \\
C_{10}\ \ O_{20} & = & \text{10 Carb. acid.} \\
H_{5}\ O_{5} & = & \text{5 Water.}
\end{array}\right.
$$

$$
C_{28}N\ H_{13}O_{30} \qquad C_{28}N\ H_{13}O_{30}
$$

Citrates and acetates, when given by the mouth, are found to be changed by the action of oxygen into carbonates, and in this form they appear in the urine; and on this account, these salts of the vegetable acids are found to be equally efficacious as the carbonates or free alkalies, in effecting a change in the urine; whilst sometimes these disagree far less with the stomach than potash or soda. It is possible, that in the blood all alkalies combine with the albumen, and that it is this compound dissolved in the water of the blood, which keeps the uric acid in solution in the capillaries of the body. The more alkaline the water is, the greater will be its power of dissolving the uric acid; any large excess of water which may be taken into the blood rapidly passes off by the kidneys, and keeps in solution whatever urate of ammonia may have passed off unchanged.

Professor Liebig seems to think, that the appearance of uric acid in the urine of different animals varies with the quantity which the animals drink; but perhaps it may more generally be stated thus, the signs + and — being taken for "much" and "little" respectively, and the sign = for "are caused by," then,

IN THE URINE.		IN THE BLOOD.		
+ Uric acid or urates.	=	+ Non-nitrogenous principles.	=	+ Non-nitrogenised food.
				— Secretion of the liver.
		— Oxygen.		— Secretion of the skin.
		— Solvent.		— Exercise.
				— Water and alkali.

and,

IN THE URINE.		IN THE BLOOD.		
— Uric acid or urates.	=	— Non-nitrogenous principles.	=	— Non nitrogenous food.
				+ Secretion of the liver.
		+ Oxygen.		+ Secretion of the skin.
		+ Solvent.		+ Exercise.
				+ Water and alkali.

Though other things remaining the same, no doubt the quantity of uric acid deposited will vary inversely with the quantity of water.*

* According to Mr. Bowman's theory, the Malpighian bodies excrete the excess of water. Hence their size might be some index of the general relative excess of water which different animals throw off, and thus also, under certain circumstances, of the quantity of uric acid. Taking the mean diameter in the order of size, we have, horse $\frac{1}{70}$ of an inch, lion $\frac{1}{80}$, man $\frac{1}{104}$, boa $\frac{1}{400}$, parrot $\frac{1}{430}$. It is curious, that the horse and lion excrete no uric acid, man in a state of health a little, and the boa a large quantity.

CHAPTER V.

ON THE TREATMENT OF THE URIC ACID DIATHESIS.

It remains now to apply these principles to practice in those cases which may be comprehended under the term uric acid diathesis; and first with regard to exercise. This should be always regulated, as far as is possible, by the fatigue produced. That which causes perspiration, in addition to the actual benefit gained thereby, always evidences considerable exertion, and, consequently, increased respiration. Hence exercise which produces perspiration is the most beneficial; and this the more so the colder the air is, because thereby a greater amount of oxygen is absorbed. From this we can judge of the value of different kinds of exercise, always stopping short of great fatigue, which might depress the vital powers, so as to admit of the production of an excess of uric acid. It was an ancient remedy to exercise the lungs by frequent respirations; and it has lately been recommended by Dr. Holland on entirely different views. The greatest benefit which can be derived from it is, by increasing the amount of oxygen which is absorbed; and it is with this view that reading out loud may be recommended, in which, though the respirations are few (something more than half the ordinary number), still they are far deeper and more complete, and by them more oxygen is taken into the system.

Sleep, tending as it does to render the respirations as light and as few as possible, should be indulged in only so far as is necessary to repair the fatigue which exercise has produced.

Hot rooms should be avoided; but in warm countries and warm seasons, though we do not inspire so much oxygen as in cold places and seasons, yet there is less inclination to take a large quantity of food, and the secretion of the skin is increased; so that it is probable that these counterbalance each other, and in this respect there is little influence on the uric acid diathesis.

Nitrous oxide water, known also as oxygenated water, is sold by most chemists in London, and it is the best diluent in these complaints.* Soda water, though so frequently recommended because it is supposed to contain soda, very rarely contains any alkali, but consists of ordinary water, with carbonic acid forced into it; so that, excepting for the quantity of water, it is in no way beneficial; and in this respect it is not so good as ordinary fountain water, inasmuch as the atmospheric air suspended in the latter is better than the carbonic acid in the former. Water, containing nitrous oxide gas, is both beneficial for the gas as well as for the water.

* Having been found beneficial when states of defective oxygenation exist.

By the various preparations of iron we may also increase the amount of red particles in the blood, and thus influence the quantity of oxygen which is absorbed.

Perhaps the greatest practical benefit has been derived from the sesquioxide of iron; and as, according to Liebig, it is in this state that the iron exists in the red colouring matter of the blood, there seems to be some reason why this medicine should be preferred to other preparations of iron; not, indeed, that it should be given in the enormous doses which have been recommended, by which the whole intestinal canal becomes loaded, but in moderate doses, and in such a state as we know offers the least impediment to its absorption; that is, in the minutest state of subdivision. To effect this, it should be given newly precipitated from some soluble salt of iron; as, for example, from the sesqichloride or per sulphate of iron, from which hydrated peroxide of iron may be formed by the addition of carbonate of ammonia or soda. Some, indeed, seem to think (and the endeavour to introduce new soluble salts of iron seems to countenance this view), that iron can be absorbed only when given in solution; but though we are unable to explain it, yet the fact is certain, that minute particles of mercury and iron can be absorbed. We may still agree with Sydenham, who says, "I have been fully satisfied, by frequent experience, that the bare substance performs cures sooner and more effectually than any of the common preparations of it; for busy chemists make this as well as other excellent medicines worse, rather than better, by their perverse and over officious diligence."

I come now to the treatment by diminishing the non-nitrogenous principles in the blood, in which I would try to give rules which are founded on the principles of Professor Liebig's physiology.

It has been shewn, that the substances which contain no nitrogen, by combining with the oxygen which has been inspired, hinder the action on the uric acid; and it is highly probable that no albumen undergoes metamorphosis until it has served the purposes of life. These are the first principles by which the practice must be governed; and hence by far the most beneficial diet is a moderate quantity of meat, with a much smaller quantity of bread. The kind and quantities of both must be regulated by experiment and consideration of the habit and exercise of the patient.*

The quantity of starch in flour, as compared with animal food, renders it unsuitable to live only on

* So many objections have been made against an animal diet, that it may be well to give Dr. Wilson Philip's words in the sixth vol. of the Medical Transactions, p. 212. He arrives at the following conclusion from a number of experiments, viz.: "That a diet composed of a large proportion of animal food tends to lessen the deposition of lithic acid, and to increase that of the phosphates." Theory and practice seem at length likely to agree on the long-disputed point of diet.

bread. Meat alone would be far more beneficial; but in most people the process of respiration almost requires some substance which contains no nitrogen, though it should be taken in small quantities only. If the quantity of bread be small, the quantity of animal food may be proportioned to the exercise and the state of the body; for thus the changes which are going on in the tissues will be repaired, and the oxygen, finding but little non-nitrogenous substance in the blood, will act more readily on the uric acid, changing it into urea and carbonic acid. Sugar and starch comprehend much the largest part of those substances in vegetables which can be absorbed; nitrogenous and oleaginous substances are present generally in small quantities, though the relative amount of these principles varies much in different species. Thus potatoes and rice are amongst those in which most starch is found, and these are therefore most inadmissible, whilst in greens and peas there is much more nitrogenous matter, which in peas is similar to cheese. Fruits usually contain large quantities of starch and sugar: on this account apples and pears are most objectionable.

Far more minute rules for diet may be given when the Third Part of Professor Liebig's work appears, on "the analysis of all articles of diet, and the study of the changes which the raw food undergoes in its preparation." Then, for the first time, will it be in the power of the physician to prescribe a rational system of diet, which now, when the patient possesses observation, is best left to his own experience.

Among non-nitrogenous substances, fat must be included. If the formula for this is taken, as $C_{11}H_{10}O$, then 31 equivalents of oxygen are required in order to convert this into carbonic acid and water, and by taking this substance as food, so much oxygen is prevented from acting on the uric acid. Butter is only the fatty particles of milk, separated from the albuminous and watery parts: this must on no account be taken in excess. Gelatine, which forms the principal constituent of soups and jellies, may be used as a partial substitute for meat; but as the albuminous tissues cannot be formed from it, it cannot be entirely substituted for it without the strength failing.

For drink, the oxygenated water has been mentioned as best, then water which has been distilled, and therefore contains no substances whatever in solution; and on this account it is, generally speaking, the best solvent; that is, it can hold more in solution and remove more from the body than another water which, when drunk, already contains some substances dissolved in it. But this water cannot be procured everywhere, and therefore it is desirable to point out how the best drinking water can be obtained. Some direct it to be filtered; and this removes all the substances which are suspended in the water, but none of those which are dissolved in it. These cannot be stopped by the filter, but they pass through with the water. Others direct that the water should be boiled: this boiling drives off carbonic acid gas which was dissolved in the water, and gave it the power of holding carbonate of lime (chalk) in solution; so that by boiling carbonate of lime is deposited, and all other substances which were suspended in the water become more aggregated, so that they are more quickly and more entirely deposited.

But neither this method nor that of Dr. Reid, who removes the free carbonic acid gas by adding a little more lime, causes any other salts of lime which may be dissolved in the water to be precipitated. To effect this, a few grains of carbonate of potash or soda should be added to the water before boiling, and the boiling should be continued for some minutes. By this means, these salts of lime will be decomposed, and sulphate of potash and soda, or chloride of potassium or sodium in very small quantities, will exist in the water after it has been filtered or the chalky sediment has been allowed to settle to the bottom. Good fountain water, or soda water, are far better than beer and wine, which are objectionable for the spirit and sugar which they contain. The spirit is a substance which may be represented by C_4H_6O, and the sugar by $C_{12}H_{14}O_{14}$; the first requiring 12 equivalents of oxygen, and the last, 24, to convert them into carbonic acid and water. The excess of sugar and acid in home-made wines renders them more injurious than foreign wines or spirits, of which gin and whisky most certainly also retard oxygenation, yet, by producing an excess of water in the urine, they cause that deposit which arises from the want of action of the oxygen to be dissolved, and thus the evil which they and other substances occasion is for a time concealed.

We can also diminish these non-nitrogenous bodies in the blood by aperients which act on the liver. These will be found more particularly useful when the deposit is dark-coloured; indeed, the deeper the colour the less action there is of the liver. We see that when no bile is removed from the liver, the deposit is more deeply coloured than at any other time. Of such medicines, calomel, aloes, colchicum, and colocynth are beneficial, both in large and purgative doses, and also when given in such a way as to increase the secretion of the liver. Hence the efficacy of blue pill as an alterative. A compound of aloes and colchicum was boasted of by Rhasis, "so far as to say that they can make such as are fain to ride to go on foot again." The use of these medicines as purgatives must be judged of by their effects and the strength of the patient. No general rule can be given other than that the stronger the patient, the more active may be the dose, and the longer it may be used; but in all cases any continued course of mercury should be avoided, and perhaps it is as well to use it only in cases of necessity. That it promotes changes in the system, even more rapidly than alkalies, is un-doubted; and from this its beneficial as well as injurious action results, and by this is explained why many have found air and exercise alone accomplish that for which a course of mercury had been prescribed.

Sudorifics are occasionally given with great advantage. With regard to baths generally, their action may be considered to be on the nerves and on the blood, and on each the action is of two kinds: thus on the nerves there may be a stimulant or sedative action, and on the blood they are capable of removing substances from it, and of enabling them to be absorbed into it. These modes of action depend on the state of the system, the temperature, and the substances which are dissolved in the bath. In one point of view the skin may be looked on as an expansion of the nerves of sensation; and by acting on the nerves of sensation, the whole system may be influenced. The following is a most interesting extreme case which admits of no other explanation: "On the 10th of April, 1777, we got near enough to Sandy Hook to make a signal for a pilot; and when the gun was fired, although every possible precaution was taken to prevent the effects of the shock on the scorbutics, two of them died instantly." —Thompson on Scurvy, p. 81.

The action of the bath on the nerves of sensation depends on its temperature as well as on the state of the system; thus, in some states, a warm bath causes irritation, and in others it acts as a sedative, whilst the same is the case with cold applications; and the greatest possible effect on the nerves is occasioned by a rapid change of temperature, as is practised in Russia, or by causing it to strike the nerves with force, as in the douche. The cold douche most rapidly cools down the part to which it is directed, and thus induces more changes in that part. Thus Liebig, p. 253, says: "Let us suppose that heat is abstracted from the whole surface of the body; in such case the whole action of the oxygen will be directed to the skin, and in a short time the change of matter must increase throughout the body."

The removal of substances from the blood depends also on the temperature of the bath and the state of the system, and for this the vapour bath is most efficacious, and has been popular from the savages of North America and the peasants of Russia, up to the luxurious inhabitants of Pompeii.—Kidd's Physical Condition of Man, p. 116, 2nd Ed.

The absorption of substances by the skin does not appear to depend on the temperature, but on the state of the system, and on the substances which are contained in the bath. This method of treatment is usually neglected by physicians, though from time to time attention has been directed to it. A great part of the benefit derived at Teplitz by those subject to the gout depends on the absorption of alkalies by the skin. That these actually enter the system, even when used as a foot bath, as the physicians there assert, is confirmed by the following statement of Professor Liebig, p. 62. "The acetate of potash given as an enema, or simply as a bath for the feet, renders the urine alkaline—Rehberger in Tiedemann's Zeitschrift fur Physiologie, II. 149;" and the change which the acetic acid here undergoes cannot be conceived, without the addition of oxygen, as it is converted into carbonate of potash. It is in the state of carbonate that the alkalies exist in the waters of Teplitz, and if the acetates are absorbed and converted into carbonates, and in this form appear in the secretions, there can hardly be a doubt that the carbonated alkalies are also absorbed and act on the blood and secretions, as the physicians at these and other baths believe. See also Absorption by the general Surface, Müller's Physiology, p. 251.

When the system is saturated with moisture the same amount of absorption cannot be expected as when a large quantity has been removed by the secretions during the night, and on this account, practical experience has directed the baths to be taken early, before food; and it has been remarked, that the effect of the bath is much lessened if the waters are drunk previous to it. Theory points out therefore that two kinds of baths, used in immediate succession, would be of the greatest benefit in the uric acid diathesis. This is the vapour bath, to remove water and acid substances from the blood, and immediately afterwards an alkaline water bath, by which alkaline water may be taken into the blood. I am not aware that this plan has been hitherto attempted, but the benefit derived at Teplitz renders its success highly probable. Warm clothing, more especially flannel, should be constantly worn in order to promote the excretion from the skin.

The next point in the treatment that must be attended to is to keep all the uric acid in the ultimate textures in solution. This may perhaps be effected by water and alkalies. When these or their carbonates are given, they should be taken and dissolved in water at least an hour before food, in order that they may not interfere with digestion; but though these medicines may relieve the complaint, they never can cure it; and being too often the only means employed for the cure of the uric acid diathesis, their continuance becomes absolutely necessary for the patient. I believe these medicines are the least necessary part of the treatment which I have laid down, and it would be well for all to try what may be effected by diet and exercise before they resort to alkalies; which may in some cases, perhaps, be the cause of an increase in the quantity of uric acid: this appears to be the opinion of Pelouze in his late report. However, those who are weak and unable to take exercise may gain great temporary benefit from their use, always remembering to take the least possible quantity, that they may be the more easily relinquished.

When the urine deposits crystals of uric acid, which may be recognized by their insolubility by heat, when they are soluble in an alkali, then alkalies are required to neutralize that acid which has set free the uric acid, and it must be given in such quantities as is found requisite to combine with all the uric acid which is formed, when the deposit will either disappear altogether, or be changed for the urate of ammonia, which is soluble by heat alone without the addition of any alkali. But by care in diet to abstain from all vegetable acids, a crystalline deposit of uric acid will rarely occur, although the amorphous deposit of urate of ammonia will do so from the causes which have been mentioned, even though no acid food or drink whatever be taken.

In connection with alkalies I think it will be well to say a few words on salt, from which the alkali in the blood is most probably derived. Salt can by no means be considered only as a luxury, but as a substance as essential to life as nitrogenous and non-nitrogenous food and water. Without salt, or some other mineral substance which can be substituted for it, as chloride of potassium, no solid substance could be taken into the system; nor, if it could be taken into the blood, could the albumen there be retained in solution; nor could the changes which are requisite for life take place in the tissues; nor could any bile be formed. As hydrochloric acid is found in the stomach, and soda in the bile and blood, it must be supposed that there exists some power in the body by which the chloride of sodium is decomposed.

Dr. Prout, in his Bridgewater Treatise, p. 496, supposes this to be electricity, and compares the liver and the mucous membrane of the stomach to the poles of a galvanic circle. By whatever means the decomposition of salt takes place, the fact is highly probable; and that a certain quantity of alkali, which is liberated in consequence, is employed in the formation of bile, and thus at least, secondarily, is necessary for the changes going on in the body, can scarcely be doubted. Liebig says, p. 161, "The presence of free muriatic acid in the stomach, and that of soda in the blood, prove beyond all doubt the necessity of common salt for the organic substances."

The effect of salt in promoting the action of oxygen on the substances in the body is seen in the fact, that no animal can be fattened if it is able to obtain much salt, and the experiment used to be fearfully tried in the navy. The habits of sailors when on board ship, excepting only their spirit drinking, are exactly those which promote the action of oxygen in the greatest degree; and when long fed on salt meat, which furnishes an abundant supply of alkali to the blood, whilst they are deprived of non-nitrogenous food, an excessive action of oxygen on the tissues of the body takes place, and when this is long continued the scurvy appears, the salt hastening the rapid changes in the tissues. Very soon after the discovery of oxygen, and when the study of organic chemistry was scarcely begun, when vegetables were thought to be a means of supplying oxygen to the body, a want of oxygen was said to be the cause of scurvy. See Dr. Trotter's Observations on the Scurvy, 2nd Edit. Dr. Beddoes inclines to the same theory. The want of coagulation of the blood, which he contrasts with that in phthisis, may be explained by the excess of alkali and salts in this disease, whilst in phthisis, from the large excretions, they can exist only in small quantities.

By diminishing the amount of alkali in the blood, and by giving non-nitrogenous food, the scurvy is cured, or prevented, in consequence of such substances being acted on instead of the tissues of the body. No other explanation can be given of the benefit which arises from vegetable acids, from fresh vegetables, from sugar, wine, beer, wort, treacle, potatoes, &c., all which have been used with the best effects. It is also a striking fact, that the scurvy makes its appearance after a storm, when the seamen have undergone violent exercise.—Beddoes, p. 50. It is extremely probable that when excess of alkali exists in the blood, the vegetable acids, instead of passing through the system, combine with the alkali; and the salt which is formed, after being converted into carbonate by the action of oxygen, is carried out of the system. In all respects the scurvy may be looked on as exactly the converse disease to gout; and the freedom of sailors from calculous affections (according to the Medico-chirurg[l]. Tran[s]., Vol. XVI. p. 103, not one case of stone occurred from 1st of January, 1816, to 1st of January, 1829, in which time there were 331,000 men employed in the naval service) is explained by the causes which render them liable to scurvy.

There are few persons now to be found who would call in question the efficacy of lemon juice in scurvy, and probably not many who would mention any thing more likely to produce a fit of the gout in one disposed to it than punch made with much lemon juice.

CHAPTER VI.

ON THE GOUT.

It will perhaps be more useful here, instead of relating single cases which have derived benefit from the mode of treatment which these views have pointed out, to shew how physicians and others, from the earliest ages to the present, have employed a practice corresponding to that which has been here insisted on, though in searching for the causes of the benefit which has been derived they have generally neglected all consideration of the part which the action of oxygen plays in the cure of these diseases.

Gout is the invariable result of the long continuance of the uric acid diathesis; and if we look to what is stated by authors on the causes and remedies in gout, a ready explanation of the mode of action of both will be given by these views of Professor Liebig's; according to which it is most probable, that great weakness and inordinate muscular exertion may increase the amount of metamorphosis in the tissues, and thus give rise to new substances, which must be oxydised in order to be removed, whilst excessive eating, sleeping, and want of exercise, constipation, vegetables, and little secretion by the skin, all produce the same effect,—all lessen the amount of oxidation which is necessary to remove those substances which result from the metamorphoses of the tissues of the body.

It will be found that physicians in all ages have insisted upon some of these as the cause of gout, and have recommended the opposite of these, as temperance, early rising, moderate exercise, alkalies, and medicines which act on the liver and the skin, as the means of cure. In the language of Professor Liebig, they have declared that the want of oxygen is the cause of gout, and the promotion of its action the only means of effecting a cure, or of hindering a return of the complaint.

Thus Galen says: "Though in the time of Hippocrates eunuchs were not afflicted with gout, yet they are now, in consequence of too much sloth and intemperance. Truly in the time of Hippocrates, on account of their temperance and extreme moderation, on the whole few suffered from gout; but in our times luxury and indulgence being so much increased that it is impossible they can be more so, the number of those who have the gout is infinite." —Galen, Comment on Aph. xxviii. sect. 6.

"You cannot give much relief to those who are incontinent, drunkards, or gluttons, either by purgatives or by bleeding; but if they follow your directions, you will benefit them most by bleeding early in the spring, and then paying attention to exercise and diet."—Galen, Treatise on the Cure of Diseases by Blood-letting, cap. vii.

In the medical observations of Schenkius, p. 681, there are many cases under the head of "Rich men living in luxury, ease, and indulgence, becoming poor, are freed from their gout by a sparing diet and bodily exercise."

Sydenham, in his Treatise on the Gout, says: "All digestive remedies whatever, whether courses of physic, or diet, or exercise, are not to be taken up by the bye, but must be used constantly and daily with the greatest diligence: for he that for many years together has indulged himself in surfeiting and drunkenness, and neglected his wonted exercises, and is worn out by sloth and negligence, or by hard study, or continual or intense thinking, or by some other errors of life, he labours in vain, endeavouring to drive away this disease by this or that remedy or regimen now and then used."

"But the exercise of the body is more advantageous than all other things that are used to hinder the indigestion of the humours, which I reckon the chief cause of gout. If this be omitted, nothing which has already been found out will do any good. But whether any one eats flesh sooner or later, great care must be taken that they eat no more during the fit than is necessary to sustain nature; and though the pain as well as the unfitness for motion may seem to contra-indicate exercise, which I have commended above all things, yet this labour must be undertaken. But it is to be observed, that it is best to use exercise in a good air; namely, in the country and not in the city. The same exercise does somewhat prevent the stone, which an easy life most commonly causes."

Sir W. Temple, himself also a sufferer from the gout, says, "The plenty of their fortunes from those great employments, and the general custom of living in them at much expense, engage men in the constant use of great tables, and in frequent excesses of several kinds, which must end in diseases when the vigour of youth is past, and the force of exercise, which served before to spend the humour, is given over for a sedentary and inactive life. These I take to be the reasons of such persons being so generally subject to such accidents (gout) more than other men, and they are so plain, they must needs occur to any one that thinks."—Sir W. Temple's Works, Vol. III. p. 241, Edit. 1770.

"It (the gout) hardly approaches the rough and the poor, such as labour for meat and eat only for hunger, that drink water either pure or just discoloured with malt."—P. 258.

"The rhyngrave who was killed last summer before Maestricht told me his father, the old rhyngrave, had been long subject to the gout, and never used other method or remedy than upon the very first fit he felt to go out immediately and walk, whatever the weather was, and as long as he was able to stand. If it continued or returned next day he repeated the course, and was never laid up with it."—P. 257.

"Let the disease be either new or old, and the remedies either common or of foreign growth, there is one ingredient of absolute necessity in all cases.

For whoever thinks of curing the gout without temperance, had better resolve to endure it with patience."—P. 261. "But that which I call temperance, and reckon so necessary in all attempts and methods of curing the gout, is a regular and simple diet, limited by every man's experience to his own easy digestion, and thereby proportioning as near as can be the daily repairs to the daily decays of our wasting bodies."—P. 263.

Cullen considered that a cure was impossible by medicines, but that it may be entirely prevented by constant bodily exercise and by low diet.

Some have extolled sudorifics, others medicines which act on the other secretions, as colchicum and mercury; others have trusted to alkalies, and others to abstaining from acids. I have shewn how these probably promote the action of oxygen, and thence the benefit derived from them in the treatment of gout; but whilst diet is neglected, no remedy will effect much either in the way of prevention or of cure. In this respect we may approve of the Homeopathic attention to diet, which, in the large class of cases included between indigestion and gout, has proved more efficacious than medicine.

In Austria a mode of treatment has been revived which, in those who can endure it, is most beneficial in the diseases which may be included in the uric acid diathesis, as indigestion, bilious complaints, gout, rheumatism, and skin diseases. At Gräffenburg, in Austrian Silesia, under Priesnitz, the action of oxygen is promoted to a most beneficial extent in these diseases, but to a no less disastrous one in the opposite class of diseases, which arise from too much action of oxygen on the body, as in phthisis and scorbutic cachexia. Until Professor Liebig directed attention anew to the action of oxygen on the human body, the causes of success and failure were unknown. At Gräffenburg, which is among the mountains near Frieburg, the greatest possible action of the skin is produced by baths. Large quantities of water are required to be taken. Early rising and a plain though not strict diet is ordered. By these means the action of oxygen on the body is promoted to a very great degree; "and death ensues if ever the system is no longer able to furnish matter to resist the action of oxygen;" the condition of health consisting in an equilibrium among all the causes of waste and of supply; "and death being that condition in which all resistance on the part of the vital force to the action of oxygen entirely ceases."—Liebig.

There is much also of the treatment at Leamington which may be explained in the same way, and thence the benefit which is in many cases derived from it. At first, abstinence and drastic medicines are ordered, and the strictest diet is enjoined, which consists chiefly of meat with a small quantity of bread and no fermented liquids, and much exercise. One hour's walk at the least before each meal. Large doses of iron are afterwards given. The waters containing, according to the analysis of Dr. Thompson, a considerable quantity of common salt, chloride of calcium, glauber's salt, and traces of iron, would assist the more energetic measures of Dr. Jephson in promoting the action of oxygen in the body, which is soon indicated by the altered complexion. In the opposite class of cases there exists quite as much danger from this treatment as I have stated above belongs to the water cure.

Many of the German baths, as Teplitz, Marienbad, Carlesbad, Kissingen, Emms, and Weisbaden, are beneficial in gout, but not so much so as the above plans of treatment, because the privations are not so great, and the other means used for promoting the action of oxygen are not so heroic; however, in the composition of the waters themselves they are superior. The comparison between what has been pointed out as the best theoretical treatment of gout, and the results of practice, as stated in Dr. Richter's Eaux Thermales de Teplitz, Edit. 1840, is as close as is possible.

It would seem that the drinking of alkaline or earthy carbonates with small quantities of iron, as well as warm baths of the same waters, that early rising and exercise, that temperance and simple diet and warm clothing, are nearly all the chief means of promoting the action of oxygen on the body. Indeed, excepting purgative medicines and active exercise, these include all the practice I have laid down in the treatment of the uric acid diathesis.

And in the cases in which purgative medicines and strong exercise cannot be taken, and are not advisable, then the above practice would be the best that theory could point out.

At Teplitz, nearly two-thirds of the visitors suffer from gout.—Dr. Richter, p. 106. The waters which are drunk are the gartenquelle, which is cold, and the hauptquelle, which is hot. The first contained, according to the analysis of Ficinus, when ten pounds of water were evaporated to dryness, 47 grains of solid residue, of which 28·9 grains consisted of carbonated alkalies and earths, with a trace of iron. The second spring contained 48·4 grains of solid residue, of which 32·1 are carbonates. Both springs also contain chloride of sodium and potassium, and small quantities of sulphate of potash and soda, which are purgative salts. From three to six goblets of these alkaline waters are drunk, with intervals of a quarter of an hour between each glass, commencing between six and eight in the morning.

The last of these springs, and others of nearly the same constitution, are used as baths; as complete baths as well as hip or foot baths, during from fifteen minutes to an hour before breakfast. By this means the amount of absorption is increased, and I would here repeat, that even an alkaline foot bath has been found to render the urine alkaline. After the bath, perspiration is promoted, and warm clothing is enjoined:—"Besoin de se vêtir plus chaudement que de coutume:" p. 155. Of the regulations with regard to diet, the two principal are temperance and simple diet: "Deux de ses lois diététiques sont fondamentales, la tempérance et une nourriture simple."

On one point only do the principles which I have set forth as increasing the action of oxygen differ from the practice at Teplitz. Animal food is directed to be lessened in gout: the reason for this is given in note 88: " Ces maladies (calcul, gravelle, et la goutte) étant dues à la formation trop considerable d'acide urique dans l'organisme, une alimentation animal comme toute substance azotée, ne peut que favoriser cette formation." This is directly opposed to the experiments of Dr. Wilson Philip; moreover, it is not from changes which take place in the food, but from those which take place in the tissues, that uric acid is produced. Excess of animal food may cause a plethoric state, while vegetable food causes a deposit of fat, and hinders the changes which might take place in the uric acid.

The above sketch shews why Teplitz has proved so advantageous in gout, and from these principles we may deduce in what cases it will be most beneficial. There the alkalies are absorbed by long-continued baths, rather than by much drinking, and but little purgative salts are contained in the waters, whilst the country around is not so attractive to those who take walking exercise as to those who ride or drive. Hence those in whom the gout is connected with obstructions of the liver will gain more advantage from more purgative mineral waters, and those who are able to take exercise on foot will find more inducements to it in other watering places; where also more alkali is absorbed in consequence of more water being drunk, and where the excretory action of the skin is a consequence of exercise. Hence at Teplitz those who are weak or unable to take exercise by walking, or to endure strong purgatives, will find the greatest relief, whilst those in whom the gout is accompanied by obstructions of the bowels or liver, and who are strong, will find more benefit at Marienbad, Carlesbad, or Kissingen.

In accordance with this, Dr. Richter says, that these places are more efficacious "à la goutte compliquée de grands embarras des voies digestives ou d'engorgements des viscères du bas-ventre, et sont préférables dans la goutte regulière et sur des sujets forts et robustes." It is hardly possible for theory and practical experience to agree more closely.

Some benefit is also derived from the mere travelling to any of the German baths; that is, passing so many hours in the air causes some increase in the action of the oxygen. The sea-sickness or nausea decreases the quantity of food, and sometimes removes bile. The early rising and exercise, when at the spring, increase the amount of oxygen absorbed, and promote perspiration. The quantity of water drunk, especially if it contains alkalies, neutralizes acids, and enables the tissues and the uric acid to be more acted on by the oxygen, to be retained in solution, and to be thrown out by the kidneys.

All explanations with regard to the proximate cause of gout have hitherto been unsatisfactory, and indeed even now a perfect one cannot be given. The older physicians thought that it depended on a certain morbific matter always present in the body, and that this matter, by certain causes thrown upon the joints or other parts, produces the several phenomena of the disease. Cullen defined it as an atony of the extremities. He says: "In some persons there is a certain vigorous and plethoric state of the system, which at a certain period of life is liable to a loss of tone in the extremities. This is in some measure communicated to the whole system, but appears more especially in the function of the stomach. When this loss of tone occurs, while the energy of the brain still maintains its vigour, the vis medicatrix naturæ is excited to restore the tone of the parts, and accomplishes it by exciting an inflammatory affection in some part of the extremities. When this has subsisted for some time, the tone of the extremities and of the whole system is restored, and the patient returns to his ordinary state of health."

In a treatise "upon gravel and upon gout," published in 1796, Mr. Murray Forbes supposes the lithic acid is constantly present to a certain degree in the circulating fluids, and that it is precipitated by the introduction of other acids; and in this manner he explains the influence of acid wines in inducing gout. He conceives the circumstance chiefly constituting this disease as being an inflammation in parts of which the functions have been interrupted by the redundant acid precipitated.

The explanation which Professor Liebig's views lead to is, that gout is an inflammation in parts in which the usual changes, which the oxygen effects, are unable to take place, in consequence of an excess of the non-nitrogenous principles in the body;* whilst rheumatism, or "the universal gout," seems to arise from the changes being checked by the action of cold on the skin.

Though this be the proximate cause of gout and rheumatism, yet there are some points which must be determined before the whole of the phenomena of these diseases can receive a perfect explanation. Of these, one is the question whether the uric acid is, in the state of health, produced in the ultimate textures, and there undergoes its changes into urea, in which state it is carried to the kidneys by the circulating blood (and the existence of urea in the blood in Bright's disease and in cholera is in favour

* This theory is only a step beyond the others which have been given; all must be imperfect until the phenomena of inflammation are understood: and though it may be shewn that inflammation is probably only a limited process of oxidation, whilst fever is the general one, and that the treatment of both is that which hastens this process to a termination rather than subdues it, still sufficient proof is as yet wanting, and though the word inflammation is not understood, still no better one can be used.

of this view), or whether in the ultimate textures some other substance is first formed from the tissues, which, when it arrives at the kidneys, is there changed into uric acid, and afterwards into urea, in the way that has been pointed out. If this last be the case, the substance out of which the uric acid is formed must exist in the blood; and it is amongst those substances which are comprehended under the term, indefinite extractive substances of the blood, that search must be made for it.

The probability of some such substance existing is increased by the most accurate examination having as yet failed to detect uric acid or urea in healthy blood, which, if the first hypothesis be true, must exist there. It is probable that when "the question is fairly driven," chemistry will soon return an answer. But whether it be urea, uric acid, or some previous substance out of which these are formed, which exists in the blood, the quantity is so small, and it is so quickly removed and changed by the kidneys, that no satisfactory conclusion can be derived from an examination of small quantities of blood.

Certainly in gout the one or other of these states must exist; either there is an excess of that substance which is capable of producing uric acid when it comes to the kidneys, which is passed during an attack of gout from the systemic capillaries to those of the kidney, and there gives rise to the excess of uric acid which appears in the urine, or, what is perhaps more probable, urate of ammonia itself (formed from the metamorphosis of the tissues) exists in the blood in larger quantities than usual. One or other must exist in the blood, during the fit of gout, in larger quantities than in the state of health, and from one or other the excess of uric acid appears in the urine; and most probably it is the presence of this substance in the circulation, and the interruption by any causes, as cold, and weakness of circulation, of the changes which it is undergoing in the capillaries and in the kidneys, that produces the phenomena of retrocedent and irregular gout.

The acid state of the secretions of the skin, the stomach, and the urine in this disease, has led some physicians to consider acidity as the cause of the disease, and to direct all their remedies to this point alone; but this state of acidity arises also from a want of action of oxygen on the non-nitrogenous principles, that is, from the oxygen not being present in sufficient quantities. In the state of health, when enough oxygen is absorbed, the lactic and acetic acid which are formed from the starch, sugar, gum, and other non-nitrogenous food, are converted into carbonic acid and water, the first by combining with 12 equivalents of oxygen, and the last with 10, thus:—

$$\begin{array}{lcl} \text{Lactic acid} = C_6\,H_5\,O_5 \\ \text{12 Oxygen} = \qquad O_{12} \end{array}\Bigg\} = \Bigg\{ \begin{array}{l} C_6 \quad O_{12} = \text{6 Carbonic acid.} \\ \quad H_5O_5 = \text{5 Water.} \end{array}$$

$$\overline{C_6\,H_5\,O_{17}} \qquad \overline{C_6\,H_5\,O_{17}}$$

and

$$\begin{array}{lll} \text{Acetic acid} = C_4\,H_5\,O_3 \\ \text{10 Oxygen} = \quad\quad O_{10} \end{array}\Bigg\} = \Bigg\{ \begin{array}{l} C_4 \quad O_8 = \text{4 Carbonic acid.} \\ \quad H_5\,O_5 = \text{5 Water.} \end{array}$$

$$\overline{C_4\,H_5\,O_{13}} \qquad \overline{C_4\,H_5\,O_{13}}$$

But in gout the deficiency of oxygen renders such changes impossible, and the acids which are formed being only partly, and in some cases not at all, acted on by the oxygen, remain in the body undecomposed until they are thrown out in every possible way, to the great relief of the system generally. This may be seen by putting blue litmus paper to the skin, when it is quickly reddened by the action of the acid which is secreted, and an increased quantity of the acid is removed by increasing the action of the skin, either by bath or by exercise. By soda, potash, or magnesia taken as medicine, these acids are neutralized, as well as by the carbonates of these alkalies which are decomposed, lactates or acetates being formed. Hence the benefit which has been derived from alkalies in gouty complaints, but it is only palliative. Such treatment does not hinder the formation of fresh lactic acid. To effect this, all the substances from which the acid most readily arises, that is, all non-nitrogenous food, especially starch and sugar, should as far as possible be left off, and the quantity of oxygen must be increased to effect a change in that lactic acid which remains in the circulation.

By this action of oxygen, then, an explanation is afforded of the effects of weakness, excessive sleeping, excessive eating, of a want of exercise as well as of inordinate muscular exertion, of vegetable acids, and of alcohol, in the production of gout. For the weakness and inordinate exercise tend to the excessive production of uric acid, disposing to and causing rapid changes in the tissues. Sleep lessens the quantity of oxygen which can be absorbed, by lessening the number and strength of the respirations, and in consequence the uric acid which is formed is not changed. By excessive eating, the blood becomes loaded, and contains an excess of those principles which can only be carried off by the action of the oxygen. By acids, the uric acid is rendered less soluble, and therefore less easily acted on. Wines are injurious from the alcohol they contain, and acid wines are doubly injurious by both acid and alcohol adding to the excess of non-nitrogenous substances, for which the oxygen has a greater affinity than it has for the nitrogenous substances.

Additional strength is given to this view, if on the other hand we look to the mode in which gout is cured or prevented. It will be seen that abstinence alone will cure, by supplying no fresh fuel, whilst the draught by respiration, that is, the supply of oxygen, remains undiminished, and gradually consumes those non-nitrogenous (carbonaceous) substances which had previously been heaped up so as to threaten to put an end to all action. Exertion increases the respirations and causes thus more oxygen to be absorbed, and so more action takes place. Purgatives remove the bile, which contains an excess of carbonaceous matter, on which the oxygen would otherwise act to the hindrance of its action on the nitrogenous substances; whilst alkalies and water hold the uric acid dissolved, and promote the changes in the tissues.

By these views, also, the relation of gout to acidity, to uric acid, and oxalate of lime calculi, is most plain. They all arise from the same cause, the want of action of oxygen. The calculus is only one or two steps further than the gout towards the state of health, towards that end which nature in most diseases endeavours to attain; for the evils to which the uric acid would give rise if it remained, can be prevented by its passing off unchanged, as in the case of the uric acid, or only partially changed, as in the case of oxalate of lime, though this is at the risk of an accumulation taking place in the kidneys or bladder; and that head-ache, heaviness, wandering pains, frequently come on when the accustomed deposit of uric acid ceases, is well known to those who constantly suffer from the uric acid diathesis.

In all constitutions predisposed to gout, the rule of Sir W. Temple as regards diet is the most in accordance with reason. It is given almost in the very words of Liebig's language:—"Simple diet, limited by every man's experience to his own easy digestion, and thereby proportioning, as near as well can be, the daily repairs to the daily decays of our wasting system." Some have restricted themselves to vegetable diet alone, but inasmuch as the amount of animal food which is required to supply the daily decays of the system is far less than the amount of vegetable food which will effect the same, and the benefit which is derived from temperance may be taken to be inversely proportionate to the quantity of food which is taken, therefore simple and moderate animal diet, or a milk diet, will be found far more efficacious than a diet consisting of vegetables, which contain a large quantity of non-nitrogenous principles. This will at least be the best as long as inflammatory symptoms are absent.

When meat is inadmissible, bread is the best substitute, on account of the large quantity of fibrin (gluten), and the comparatively, as regards vegetables, small quantity of non-nitrogenous substance (starch) which it contains.

In the composition of the muscular substance of brown or white meats, fish or fowl, animal chemistry can detect no difference, which may be practically applied by the physician. Those which are fat must be avoided; in other respects, experience will be the best guide.

I cannot possibly sum up the indications of treatment in this disease, which the theoretical views of Professor Liebig suggest, better than in the words of the most practical and celebrated physician of

Germany, which state the general indications as being,

"1st, To neutralize any diseased products which may be formed.

"2ndly, In proportion as they are formed, to cause them to be removed, in order to prevent any accumulation which might cause a paroxysm.

"3rdly, To render the formation of any fresh diseased products impossible." — Schönlein's Lectures, 1838.

How these may best be fulfilled is the subject of the chapter on the Treatment of the Uric Acid Diathesis, to which I must refer in order to avoid repetition here.

CHAPTER VII.

ON THE OXALIC ACID DIATHESIS; AND ON THE PRODUCTION OF OXALIC ACID FROM URIC ACID.

1st. *On the Oxalic Acid Diathesis.*

ALTHOUGH it appeared, from the examination of the urinary calculi in different collections, that those which contained oxalate of lime bore a very considerable proportion to those in which uric acid was present; and though the former has even been found in some, as in the collection at Wurtemburg, more frequently than the latter, still the number of patients who suffered from the oxalic acid diathesis seemed to bear the greatest disproportion to the number of those in whom the uric acid diathesis existed. The intermixture, and alternation also, of oxalate of lime with urate of ammonia or uric acid was found to be very frequent in calculi. No explanation could be given of these facts. The one seemed to point to some intimate relation between these substances, to some origin from a common cause; whilst the other appeared to prove, that whenever oxalate of lime was formed, it almost always remained and produced a calculus. The researches of Professor Liebig have shewn the high probability of the first conclusion, and the microscope in the hands of Dr. Bird* has shewn the error in the last, by detecting crystals of oxalate of lime very frequently in the urine.

Usually the diathesis has been recognized in consequence of a small calculus of oxalate of lime being passed. Now, however, by means of the microscope, the physician may much sooner obtain evidence of this diathesis, which will be rendered all but certain when a substance is obtained which does not effervesce when mixed with a dilute acid, though it does so after a moderate heat has been applied, and again ceases to do so after exposure to a strong heat, with which the ash becomes alkaline, and when dissolved in water gives a white precipitate with oxalate of ammonia.

2ndly. On the Production of Oxalic Acid from Uric Acid.

The frequent intermixture in calculi of urate of ammonia and oxalate of lime shews some intimate connection between the two, which, by the investigations of Professor Liebig, can now be explained. In mentioning the changes which uric acid undergoes, it has been stated, that oxalic acid may be actually produced from uric acid whenever it is subjected in our laboratories to the imperfect action of oxygen.

* See Medical Gazette, July, 1842.

The changes which take place may be represented thus :—

$$\left.\begin{array}{lr} \text{Uric acid} = & C_{10}\,N_4\,H_4\,O_6 \\ \text{4 water} \;\; = & H_4\,O_4 \\ \text{2 oxygen} = & O_2 \end{array}\right\} = \left\{\begin{array}{ll} \text{Urea} & (C_2\,N_2\,H_4\,\,O_2) \\ \text{Alloxan} & (C_8\,N_2\,H_4\,O_{10}) \end{array}\right.$$

$$\overline{C_{10}\,N_4\,H_8\,O_{12}} \qquad\qquad \overline{C_{10}\,N_4\,H_8\,O_{12}}$$

which equal

$$\left.\begin{array}{l} C_2\,N_2\,H^4\,O_2 \\ C_2\,N_2\,H_4\,O_2 \end{array}\right\} = \text{2 urea}$$

$$C_4 \qquad O_8 \;\; = C_6O_8$$

$$\overline{C_{10}N_4H_8O_{12}}$$

now C_6O_9 = oxalic acid,
and C_6O_{12} = carbonic acid.

From this it appears, that uric acid, with the addition of three equivalents of oxygen and four equivalents of water, contains the elements of two equivalents of urea and three equivalents of oxalic acid; and when the uric acid is further oxydised, that is, when six equivalents of oxygen are added to it, then no oxalic acid is formed, but urea and carbonic acid; so that its production is, as it were, a check in a natural process, analogous to what is called by embryologists arrest of developement, the cause of this check being a want of action of oxygen on the uric acid.

In the oxalic acid diathesis, the oxydising process in the body is carried a step further than it is when the uric acid diathesis exists; but it still is stopped short of the extent to which it is carried in the state of health. From this we may deduce rules for the prevention of this diathesis, the object being to increase the action of oxygen on the uric acid, by which it may be changed into carbonic acid and urea. It is only necessary here to refer to the fourth Chapter, in which these rules are laid down. Practical experience had established very sufficient principles for the treatment of the uric acid diathesis; but in the oxalic, the want of knowledge of the most usual origin of the oxalic acid had prevented any rational rules for its prevention from being formed. It was known that sugar, by being acted on by nitric acid, might produce oxalic acid; and on this account some desired their patients to abstain from sugar, others required that no lime should be taken.

We can hardly expect any benefit from these rules when it is known that the usual source of the oxalic acid is from uric acid, and that it is absolutely impossible to abstain from lime in some form or other, as it exists in almost every thing which is taken as food and drink. 2ndly. Though it is possible that sugar, and perhaps other substances of the non-nitrogenous class, may, by imperfectly combining with oxygen, in the body give rise to oxalic acid (and it will be especially interesting to inquire whether this takes place at any time in the course of diabetes, or in diseases related to this, in which there seems to be a want of oxydation of the non-nitrogenous substances), still the oxygen has evidently a much stronger affinity for the non-nitrogenous than for the nitrogenous substances in the body, and thus the process of oxydation is far more frequently incomplete in the latter than in the former; so that we should expect oxalic acid generally to arise from the insufficient oxydation of the uric acid, and much more rarely from sugar; and the alternation of this substance with uric acid in calculi, and the ease with which it is formed from uric acid, leads to the belief that this is the usual origin of oxalic acid. The free oxalic acid passing off by the kidneys meeting with the phosphate of lime, which is secreted both by them and by the mucous membrane of the urinary passages, decomposes it, and oxalate of lime is the result.

The same thing happens when oxalic acid is taken, as such, in the food; if free, like tartaric acid, it passes off at the kidneys, and combines with the lime which it afterwards meets with. If taken in combination with alkalies, like tartaric acid, it would probably be decomposed.

The causes, then, of this disease are in most cases similar to the causes of the uric acid diathesis. Both diseases may be referred to insufficient oxydation, and the treatment must consequently be the same in both. So that it is here sufficient to refer to the chapter on the treatment of the latter: but there is one point which requires separate notice, and this is the lime.

There can be no doubt whatever that if no lime existed in the body or was taken into the system, no oxalate of lime could be formed; and it is highly probable that an excess of lime in the system may induce the formation of oxalic acid; but some lime is necessary for the bones and the membranes, and it is taken into the system in all solid and liquid food. Now, though it is impossible to obtain food absolutely free from it, and thus to hinder all formation of fresh oxalate of lime, still by rendering it as free as possible, the rapid increase of a calculus may be prevented. Perhaps of all substances water is the easiest to render pure, and it is that which usually contains most lime. On this account, in the oxalic acid diathesis, distilled water should always be used in every thing for which common water is employed in the state of health. When distilled water cannot be obtained, rain water would be the best substitute; and when this is not to be had, then that which has been purified in the way mentioned in the fifth Chapter.

The ashes which are obtained from all flesh invariably contain small quantities of phosphate of lime, and all vegetables contain some lime, and no means can be taken for separating it from vegetable or animal food; and probably the system could not endure the absence of all lime from the food. Such treatment is therefore merely palliative, and the curative treatment must be directed to the oxalic acid, and not to the lime.

CHAPTER VIII.

ON THE PHOSPHATIC DIATHESIS; AND ON THE PRODUCTION OF THE PHOSPHATES OF LIME AND MAGNESIA.

On the Phosphatic Diathesis.

THE phosphatic diathesis may be divided into a true and a false diathesis; the true being that in which, in consequence of a general state of the system, the urine becomes alkaline and the phosphates are deposited; the false being that in which alkalescence ensues from an obstruction to the urine, or from the mucus which is secreted, rapidly inducing a change in the urea,—as, for instance, when there is irritation or inflammation of the mucous membrane of the bladder.

The false phosphatic diathesis is far more common than the true. In both, the urine is always alkaline, and a white deposit occurs which is easily soluble in any dilute acid, but insoluble by heat or by alkalies. It is by no means uncommon to observe in this diathesis a layer of crystals on the surface of the water, which, when exposed to the light, presents a varied play of the prismatic colours. These consist also of the phosphates, and possess the same chemical properties as the white deposit.

On the Production of the Phosphates of Lime and Magnesia.

Dr. Prout, when alluding to the wonders of creation displayed in the adaptation of different chemical substances to the purposes of the body, says, "How truly wonderful and utterly beyond our comprehension are the properties and adaptations displayed in the processes of organization." And the illustration of phosphorus and lime is scarcely less striking than that of carbon, which he has chosen. As magnesia corresponds so closely in its chemical properties with lime, it is in consequence capable of being applied to the same purposes, either by vegetables or animals. Thus Liebig observes, "When lime exists in the ashes of plants in large proportion, the quantity of magnesia is diminished; and in like manner, according as the latter increases, the lime decreases."—Veg. Phys. 2nd Ed. p. 99. And this similarity of properties acts as a security against deficiency, and accounts for these two substances being so frequently found associated together in the human body.

Phosphorus, phosphoric acid, lime, and magnesia are carried into the circulation of men and animals, partly in their food, and partly in their drink. They exist in these in organic or in inorganic compounds. In vegetable and animal albumen no difference can be observed, even in regard to the presence and relative amount of sulphur, phosphorus, and phosphate of lime. In vegetables we find organic acids combined with lime and magnesia, and in them phosphates, carbonates, sulphates, or chlorides of lime and magnesia are universally present. " Phosphoric acid," says Liebig, " has been found in the ashes of all plants hitherto examined, and always in combination with alkalies and alkaline earths."—2nd Edit. p. 144.

Most seeds contain certain quantities of the phosphates. In the seeds of different kinds of corn particularly, there is an abundance of the phosphate of magnesia. " We may form an idea of the quantity of phosphate of magnesia contained in grain, when we consider that the concretions in the cœcum of horses consist of phosphate of magnesia and ammonia, the greater part of which is obtained from the oats and bran consumed as food. These concretions are most apt to form in the horses of millers, which are fed on bran, which contains the greatest quantity of phosphate of magnesia."—P. 92, 2nd Edit. of Vegetable Chemistry. " All plants obtain their phosphoric acid from the soil; it is a constituent of all land capable of cultivation, and even the heath of Lunëburg contains it in appreciable quantity; and it has also been detected in all mineral waters, in which its presence has been tested."—P. 144, 2nd Edit. Most spring water contains lime in some form or other.

The following table, compiled from the Animal and Vegetable Physiologies of Professor Liebig, may be useful for comparison.

1000 parts of fresh beef contain 42·3 ashes, of which 0·8 is phosphate of lime.

1000 parts of potatoes contain 49·1 ashes, chiefly phosphate of magnesia and ammonia.

1000 parts of black bread contain 32·5 ashes, chiefly phosphate of magnesia.

1000 parts of milk contain 2·5 ashes, phosphate and carbonate of lime and magnesia.

1000 parts of grain of wheat contain 9·94 ashes, chiefly phosphates.

1000 parts of blood contain 2·1 to 1·4 ashes, phosphate and carbonate of lime and magnesia.

1000 parts of urine of lion contain 7·10 ashes, 1·7 phosphate of lime and magnesia, and 9·0 phosphate of ammonia, soda, and potash.

1000 parts of urine of horse contain 11·0 to 2·0 ashes, carbonate of lime and no phosphate.

1000 parts of urine of man contain 1·0 ashes, phosphate of lime, and ammonia, and magnesia.

When the supply of phosphorus, lime, or magnesia is no greater than is required in the body for the bones, the brain, and the membranes, none appears in the urine, as in horses' urine: thus Professor Liebig says. " In the graminivora, therefore, whose food contains so small a proportion of phosphorus or of phosphates (grass containing a large quantity of silicate of potash, but only traces of phosphoric acid), the organism collects all the soluble phosphates produced by the metamorphosis of the tissues, and employs them for the developement of the bones and of the phosphuretted constituents of the brain."

" The organs of excretion do not separate these salts from the blood " (Animal Chemistry, p. 80), but when a greater supply is given than is required for use, the excess is thrown out in the excretions, or, in some rare cases, is laid up for future use. " Those animals which are ready to moult have always two stony substances, called crab's eyes, placed in the stomach, which, from the experiments of Reaumur and others, appear destined to furnish the matter, or a portion of it, of which the shell is formed; for if the animal is opened the day after its moult, when the shell is only half hardened, these substances are found only half diminished; and if opened later, they are proportionably smaller."—Kirby, Bridgewater Treatise, Vol. II. p. 55.

" The supply of phosphate of lime necessary for renewing the antlers of the deer must be supposed in part to be derived from that deposited elsewhere in the bones; for some of these antlers, as the elk's, have been known to weigh half a hundred-weight." —Good's Book of Nature, Vol. I. p. 275. If, on the other hand, a deficiency is supplied, then that which was deposited in the bones is removed to serve purposes more necessary for life. M. Chossat, in June, 1842, stated to the Academy of Sciences, that he prevented pigeons from obtaining lime, feeding them on wheat; and after ten months they died, and it was found that their bones had been acted on so as in some places to have fallen off considerably in size, and to be perforated with small holes. In other places they had disappeared altogether.

There is a second source of phosphatic salts, in consequence of the continual oxydising process going on in the body, by which the phosphorus of the albumen is converted into phosphoric acid. In those animals in which there is a rapid metamorphosis going on, as in carnivorous animals, we should expect therefore a very large amount of phosphates; and we accordingly find upwards of 10 parts in 1,000 of urine of the lion consist of salts of phosphoric acid. Even in man, when from exercise and animal food a rapid change is taking place in the tissues of the body, a large quantity of the phosphates are found in the urine, whilst during rest a much smaller quantity is usually present. This is sometimes to be seen in accidents. A labourer was brought into St. George's Hospital, with a severe wound received when at work. The urine, when examined soon after his admission, was found to give a considerable precipitate with ammonia. He was bled, confined to bed, and put on fever diet: the second morning there was scarcely a trace of phosphates in the urine.

It is probable that the salts of lime, when taken into the blood, are converted into carbonates, and remain dissolved in the free carbonic acid of the blood until they meet with phosphoric acid in the kidneys. If no phosphoric acid is formed in excess, as in the graminivorous animals, then the salts of lime and magnesia are excreted as carbonates.

The two sources then of phosphoric acid in the blood are, 1st, from the food, and, 2ndly, from the oxydation of the phosphorus of the tissues: when from these sources an excess exists in the blood, it is thrown out in the urine; and when this is the case there is an additional quantity thrown out by the secretion which takes place from the mucous membrane; for the mucus of all membranes is found to contain salts of lime, and in most cases phosphate of lime.

The deposit on the teeth from mucus and saliva contains 79 per cent. of phosphate of lime. A calculus from the sublingual duct in St. George's Hospital I found to consist almost entirely of phosphate of lime. The deposit of calcareous matter in the lungs consists of phosphate and carbonate of lime. The concretions in the prostate gland consist almost invariably of the same substance. The mucus of the bladder and urinary organs is secreted also with this substance, and when the secretion is increased by irritation or inflammation of the membrane, more mucus and a greater quantity of this phosphate of lime is thrown out than in the state of health.

The surface of the prostatic calculi of phosphate of lime is in contact with the mucous membrane, and not unfrequently receives from it so high a polish as to justify the comparison with porcelain, which, from their smoothness and polish, they have been thought to resemble; but it would be more correct to compare them to the polished inner surface of shells, which arises from the same cause, namely, the contact of the secreting mantle or membrane. It is not at all unusual to find the same pearly polish in renal calculi, when phosphate of lime has been deposited, which is in contact with the mucous membrane of the pelvis of the kidney.

The phosphates, whether derived from the mucus or from the secretion of the kidneys, are insoluble in any alkaline fluid; but very soluble in any dilute acid. The urine being, in its healthy state, always acid, these salts, in whatever quantities they are produced, are always held in solution, and they remain dissolved until the urine becomes alkaline. This may occur, 1st, by taking alkalies, whether free or in combination with carbonic or vegetable acids, and, secondly, by the urea undergoing a change, whereby it is converted into carbonate of ammonia.

$$\begin{array}{lll} \text{Urea} = C_2N_2H_4O_2 \\ \text{2 water} = H_2O_2 \end{array}\Bigg\} = \Bigg\{ \begin{array}{ll} C_2 O_4 & = \text{2 carbonic acid.} \\ N_2H_6 & = \text{2 ammonia.} \end{array}$$

$$\overline{C_2N_2H_6O_4} \qquad \overline{C_2N_2H_6O_4}$$

That is, urea, by combining with the elements of two equivalents of water, gives rise to two equivalents of carbonate of ammonia. Urea dissolved in pure water does not undergo this change, but it takes place in the urine in consequence of changes going on in the mucus, which is secreted by the membrane lining the cavity of the urinary organs. At present this mucus is looked on as a kind of ferment, and its action on the urea is considered as an instance of catalytic action. "Dans l'urine à côté de l'urée, la nature a placé quelques traces de matière animale, albumineuse, ou muquese; traces presque insensibles a l'analyse. Celle-ci pourtant, parvenue à l'air, s'y modifie, et devient un de ces fermens comme nous en trouvons dans la nature organique. C'est lui qui détermine la conversion de l'urée en carbonate d'ammoniaque."—Dumas, Leçon sur la Chimie statique des êtres organisés, p. 39.

In the healthy state, this action of the mucus does not take place until after some hours of exposure to the action of the air; but when the secreting membrane is inflamed, it appears that the mucus undergoes this change much more rapidly, and sometimes even without previous exposure to the air. In such cases it is by no means unfrequent to find that that fluid which is in contact or mixed with the mucus becomes first alkaline, and afterwards the remainder becomes so. The investigations of Dumas on ferments may be expected to throw most light on the changes which the mucus undergoes; meantime we can by no means agree with some authors, that the change of urea into carbonate of ammonia depends on a loss of vitality. This is a similar explanation to one quoted by Dr. Richter, in his Eaux Thermales de Teplitz, p. 94: "Les chemistes ne peuvent qu'analyser le cadavre des eaux." The attempts to explain one truth by the assumption of a more general one, which is neither self-evident nor can be shewn to be probable, is not the smallest advance in the path of knowledge. "It profits nothing to explain things which appear incomprehensible, on account of not having been investigated by assumptions far more incomprehensible." For example: M. Demalet, quoted by Dr. Young, on consumption, says, "The voice is not a simple vibration; it is animalised; it is alive, like the organs which produce it."

The urine is also found to be alkaline, even when it passes from the kidneys in states of great weakness, and when the spinal cord has been injured. In weakness, the sulphuric and phosphoric acids, produced by changes in the albuminous tissues, are formed in exceedingly small quantities. These acids no longer are sufficient to convert all the carbonate of lime into sulphate and phosphate, and consequently the carbonate of lime appears in the urine, or is deposited, if a nucleus exists. Hence it is, probably, that we so frequently find small quantities of carbonate of lime in phosphatic calculi. In very great states of weakness, the changes in the tissues are so slow that the smallest quantities of phosphates are produced, and then, though the urine becomes alkaline, still no sensible deposit is found in it. This may be frequently observed in the last stage of Bright's disease, in which, as appears by Dr. Christison's quantitative analysis, the formation of phosphates is greatly diminished; when it will be found that, although cream of tartar may be given, so as to render the urine highly alkaline, still it will remain entirely free from any deposit.

In injuries of the spine producing paralysis, the urine occasionally is rendered alkaline, in consequence of retention in the bladder giving time for the mucus to undergo its changes; but this explanation is not satisfactory in all cases, nor is this state of urine by any means an invariable occurrence in such cases. That some ammonia is produced by the metamorphoses going on in the substances in the body can hardly be doubted, for this must be the origin of the ammonia of the phosphate of ammonia and magnesia, as well as of the ammonia of the muriate of ammonia and of the lactate of ammonia, which Berzelius believes to exist in the urine, and it must be considered as possible for this ammonia to be formed in such quantities as may be more than sufficient to neutralize the acids which are formed, or for the formation of these acids to be so much diminished, that even the usual quantity of ammonia which is formed may not find acids to neutralize it. But on this point it is most difficult to obtain any accurate knowledge.

In whatever way the urine becomes alkaline, the phosphates, being insoluble in an alkaline fluid, are precipitated, and either form a concretion in the bladder, or are deposited from the urine as a white sediment, which is easily soluble in very dilute mineral acids, and does not disappear even with a strong heat.

There can be little doubt that when there is excessive action of the brain, and excessive changes are taking place, the phosphorus of the nervous tissues must give rise to an increased quantity of phosphoric acid, but as yet, excepting the opinion of Dr. Prout, no positive evidence can be adduced.

THE TREATMENT OF THE PHOSPHATIC DIATHESIS.

This may be palliative, or curative.

1st. Palliative. The first object must be to cause the phosphates to be retained in solution; this is effected by rendering the urine acid, which is most easily done by any vegetable acid, as tartaric, citric, acetic acids. It was found by the experiments of Woehler on men and dogs, that if any of these acids are taken in a free state, that is, not in combination with an alkali, they pass through the blood unchanged, and appear as acids in the urine. Why they should not be oxydized, as they are when taken in combination with alkalies, is at present unknown;

and why they should pass off by the kidneys is just as little understood, as why urine is secreted by the kidneys, and bile by the liver. The dose of these acids must be gradually increased until the urine becomes again acid to test paper, when great care must be taken not to render it so much so as to cause a precipitation of uric acid. The care with which the gouty avoid all acid wines and fruits shews how easily vegetable acids affect the urine and cause a deposit of this species of gravel. It has also been found by experiment (see Berzelius's Hand-book, p. 467), that the strong mineral acids possess no power to render the urine acid; probably their strong affinity for the soda in the blood causes it to leave its combination with the albumen; and thereby salts of soda would be formed, and the acids would pass off by the kidneys as neutral salts.

The amount of phosphates thrown out may be lessened by abstaining from those vegetable substances which contain much of the phosphates, as bread, and more particularly brown bread and potatoes, instead of which, peas, beans, and rice should be eaten.

Our chief attention must be directed to the removal, if possible, of the cause of the alkalescence which constitutes the curative treatment: this may be most beneficially joined with palliative measures. If the alkalescence arises from the altered mucus thrown out by an inflamed bladder, when the inflammation is cured, the acidity will return, and the deposit cease. If the irritation of a stone causes the secretion of mucus, or hinders the emptying of the bladder, the stone must be removed. If the alkalescence proceeds from weakness, it is only by restoring the general health that the urine will permanently regain its natural condition; though, for a time, and for a time only, much evil may be hindered by the use of vegetable acids. The restoration of the general health must be left to the medical man, for no general rules can be of any benefit without a knowledge of the causes on which the weakness depends.

PART II.

ON THE STONE.

ON

THE STONE.

CHAPTER I.

ON THE NATURE OF THE STONE.

Gravel and sediments, when retained in the bladder, produce stone. The varieties of stone are consequently as numerous as the different kinds of gravel and sediments. All similar crystalline particles have a tendency to arrange themselves in similar directions, and to exert a power of cohesion on each other, and the purer any substance is, the nearer its particles approach, and the greater their power of cohesion. In calculi, too, the mucus of the bladder acts as a kind of cement and unites those particles which are not sufficiently close together to admit of the action of the power of cohesion.

When once a nucleus is formed by some gravel or sediment retained in the bladder, or by some foreign body introduced from without, by which the urine is obstructed, alkalescence ensues, and the phosphates are precipitated; otherwise the urates are deposited on it, whenever they are, beyond a certain amount, dissolved in the water. What the quantity is which can be held dissolved, so as not to be deposited on a nucleus, is not yet ascertained; but it is less than the quantity of urate of ammonia, which can be taken up by the urine at the temperature of the air. This an experiment of Berzelius demonstrates. The water being passed in different glasses, he found the first quantity contained all the mucus, which he accounts for by its settling to the lower part of the bladder. This mucus was separated when the water became cold. It was dried, and then found to contain small crystalline grains of urate of ammonia; and these were found when the urine in the other glasses remained clear after cooling. He also found in another experiment, that if urine is passed in two portions, and let stand for some days, these crystals are seen to form in and upon the mucus, which is all in the first portion; whilst the second portion, which contains no mucus, deposits no crystals. These experiments shew most clearly, that the mucus acts as a nucleus on which the urate of ammonia is deposited, even when the urine contains no more than it is able to hold in solution, when no nucleus is present. The same thing happens when any nucleus exists in the bladder. Hence it may be deduced, that it is not sufficient, in the treatment of calculi, to give medicines which may cause the urates merely to be retained in solution in the urine; but if we would stop the calculus from increasing, the actual amount of urates in the urine must be lessened. How this may be effected was treated of in the First Part.

When the nucleus is exposed on all sides to the urine which contains an excess of substances dissolved in it, then the increase of the calculus takes place in regular and even layers, and generally, the more slowly the substances are deposited, the more compact the calculus is. When the fluid is not in contact with the nucleus in all parts, then the increase is only on those which are exposed to it. This happens when one side is adherent to the bladder, or when the calculus is partly encysted, or when more than one nucleus is present. The urate of ammonia, uric acid, and the phosphates, are among those substances which can be thus held in solution, and can be consequently deposited in layers, each of which is of equal thickness in each part; but the oxalate of lime cannot be held in solution, for the strong affinity of the oxalic acid for lime must cause the decomposition of the phosphate of lime the moment it comes to the surface of the mucous membrane, and even whilst in the uriniferous ducts. The particles of oxalate of lime which are formed are absolutely insoluble in water, and therefore they pass into the bladder in a state of suspension as a powder, or aggregated into masses, which, as is the case with the mucus, must fall to the lowest part, and there they attach themselves to the nucleus, and thus they give origin to that irregularity of form which, in some calculi, may be compared to the mulberry. Hence, the larger the calculus, the more partial must be the deposit, and though in small oxalate of lime calculi this warty appearance may sometimes be indistinct, yet I do not remember ever to have seen it absent in large ones of that description.

On the chemical characters of the different kinds of calculi, I think it will be better to translate a part of Berzelius, rather than to give my own observations. He says: “Their colour is different, according to their composition. They are found white, grey, yellow, and brown (and black). Their surface is either earthy, smooth, and polished, or covered with small warty excrescences, or with projecting small crystals: as long as they are moist, they usually smell like urine. According to Marcet, their specific gravity is between 1·2 and 1·9. Their form is determined sometimes from the parts on which they lie; and when many are present at the same time, they usually grind down and smooth their surfaces against each other. The greater number are oval, and they vary in size between that of a hazel nut and under, up to that of a duck's egg and over. Some have been found in the bladder, which weighed above three pounds, and had the form of a melon. The sections of these stones are the most interesting of their visible characters. By means of a fine and sharp saw, the stone is sawn in two through the middle, and the new surface is ground and polished with water and the powder which fell in sawing; and then the internal structure of the stone becomes visible. Usually there is in the middle a nucleus of some one substance, which has become surrounded with others in various layers of unequal thickness, in which way indeed some have been found to be composed of layers which contain all the ordinary constituents of stones. Many, however, consist of one substance throughout, which is deposited in distinct layers of different thickness, which are often easily separated. I will now go through separately each substance which occurs as a constituent of stone.

1st. Uric acid is the most common constituent of stone. Such calculi have a reddish brown or brownish yellow colour: sometimes they are yellow, more rarely white. Their surface is sometimes flat, sometimes covered with roundish warts. A section shews thin concentric layers, and the surface, when broken, is either imperfectly crystalline, or earthy. They contain no pure uric acid. It never occurs pure, but it is always combined with the same colouring matters which accompany it in urinary sediments, and from which calculi have a colour varying from yellow to mahogany. Æther extracts from them, as indeed from all kinds of calculi, almost always some fat of that kind which is usually present in animal fluids. A part of the yellow colouring matter can be extracted by acetic acid, by means of which the fluid is coloured yellow. In addition, they contain always either albumen or mucus from the bladder; it is difficult to say which. If such a stone is dissolved in caustic potash, and the acid precipitated by the addition of an excess of hydrochloric acid, thrown on a filter and washed until the excess of hydrochloric acid is removed, then the water which is used for washing dissolves a substance which is again precipitated as soon as it falls into the acid fluid which first went through the filter.

If this water is received into a vessel by itself, and mixed with hydrochloric acid, it is found that the precipitate has a re-action exactly like the neutral compound of fibrin or albumen with hydrochloric acid, and that its solution in water is precipitated by ferroprussiate of potash. A similar re-action belongs to the mucus of the bladder, and it seems thence to follow, that this substance exists in an exactly analogous state of combination with uric acid, as that in which it exists with hydrochloric acid.

All stones consisting of uric acid contain also small quantities of urate of potash, soda, ammonia, and frequently lime; and thence they leave, when burnt, small quantities of ashes, which consist of carbonate of potash and carbonate of lime. Sometimes they contain more or less phosphatic earth intermixed. The chemical characters whereby calculi of uric acid are recognized are the following: they are soluble in caustic potash, by which scarcely a trace of ammoniacal salt is evolved; but frequently there remains a residue of gelatinous phosphate of lime, which, when the quantity is only small, is dissolved in excess of potash. With acids, this solution gives a gelatinous precipitate, which soon collects into a granular powder.

By nitric acid these stones are quickly dissolved; the solution is yellowish, and becomes red by evaporation at a gentle heat. The substance which remains again dissolves without colour in water, and again becomes red on evaporation. The experiment is easily made on a watch-glass, or a little piece of porcelain, with a portion broken off for trial, which may be smaller than a grain of mustard; but forasmuch as too much acid and too strong a heat in evaporation destroy the red colour, and change it into a yellow, therefore it is best to make this experiment, according to Jacobson, in this manner.

The solution in nitric acid is so far evaporated that it is no longer liquid, but still not dry; the watch-glass is then turned over and laid upon another, in which a couple of drops of caustic ammonia have been put, which is then gently warmed over a lamp. The evaporated ammonia neutralizes the nitric acid, and immediately the red colour appears on the upper glass. The easiest way to detect foreign substances which are mixed with such stones consists in burning a small piece on platinum before the blowpipe. At first, one must steadily blow with the outer flame, by which a smell of burnt horn and of hydrocyanic acid is given off, whilst the calculus diminishes in size. At last there comes a time when the residue takes fire, and burns of itself with much lustre, even without blowing. In the purer kinds of uric acid calculi only a small trace of ashes remains. If much remain which are not alkaline, the stone is mixed with phosphatic earth. If, on the contrary, the ashes are strongly alkaline, but insoluble in water, the stone contains urate of magnesia or oxalate of lime, which has become caustic by burning.

2nd. Urate of soda with traces of urate of lime has never been found alone forming an entire calculus. Lindbergson found it as a constituent of a calculus, which will by-and-by be mentioned.

3rd. Urate of ammonia composes by itself some calculi; but it is rather rare, and then more frequent in children than in adults. Such stones are usually small, white or clay grey, with smooth, and at times, tuberculated surface: they consist of concentric layers, and have an earthy fracture.

After Fourcroy and Vauquelin had proved the occurrence of stones consisting of this salt, W. Brande declared their statement was a mistake, and said, that urate of ammonia never occurred in urinary concretions; that the ammonia which caustic potash evolved from urinary concretions arose, according to his opinion, sometimes from intermixed phosphate of ammonia and magnesia, but more usually from the ammoniacal salts of the urine and from the urea, of which a certain quantity, on drying the stone, became attached, and which arose from the urine with which the stone was saturated when it was extracted. However, Prout soon shewed how wrong Brande's statement was, and this has been since confirmed by many others. It is very easy to discover urate of ammonia. The stone is reduced to powder and washed with cold water, to remove any urine which remains; then it is boiled with a good deal of water, which dissolves the urate of ammonia, the greater part of which crystallizes out on the cooling of the fluid. The remainder, which is obtained by evaporating the fluid, is treated with hydrochloric acid, by which the uric acid is separated, and, on evaporating this solution, salmiak remains.

When, however, the whole stone consists of urate of ammonia, much water is required for dissolving it, and it is better at once to treat it with hydrochloric acid: of the solution which is obtained, some drops are to be taken and mixed with caustic ammonia, to see if phosphate of ammonia and magnesia is contained in it. What remains of the solution is evaporated to a mass, in which the presence of ammonia and soda is discovered by subliming the salt mass in a glass tube, closed at one end, by which salmiak, rendered impure by decomposed animal matters, sublimes, and usually some common salt mixed with charcoal remains at the bottom of the tube.

Moreover, urate of ammonia is discovered by its evolving ammonia in a solution of potash; but in this experiment an error may arise, inasmuch as the same thing happens with phosphate of ammonia and magnesia; but all doubt will be quickly removed by the addition of a little water. If it come from urate of ammonia, all will be dissolved; whilst if from magnesian salt, the magnesia remains undissolved. Calculi, consisting of urate of ammonia, are acted on by nitric acid and heat, like those of uric acid.

4th. Urate of magnesia is certainly among the rarest stones which occur; partly, because magnesia makes so small a part of the constituents of the urine, and partly, because it is one of the most soluble of the uric acid salts. It has been found by Scharling as the chief constituent of two stones, which, however, also contained urate of ammonia. The presence of this salt in stones is easy to be discovered when the powdered stone is boiled in water, wherein both the salts of magnesia and ammonia are dissolved. The solution is mixed with hydrochloric acid, which precipitates the uric acid, and the fluid which remains is evaporated to dryness in a water bath. The residue is then moistened with a little strong hydrochloric acid, and the greatest part of it again driven off by evaporation.

Absolute alcohol extracts chloride of magnesium, and leaves the salmiak behind, the proportions of which can be determined by weight. The alcoholic solution, after a little carbonate of potash is mixed with it, is evaporated; the residue is dried in a platinum crucible, and when heated until it begins to be of a red heat, it leaves the magnesia behind. The excess of potash is washed out. If it is intended to make an experiment with re-agents, a little of the stone should be boiled with water, and the boiling solution, mixed with a few drops of caustic potash, should precipitate the magnesia.

Urate of lime has never been found, except in small quantities, in stones which chiefly consisted of uric acid.

5th. Uric oxide. Marcet's xanthic oxide is a kind of urinary concretion which rarely occurs. The first was discovered by Marcet (having been passed by a patient of Dr. Babington's, of whom nothing is known). The stone weighed eight grains, and had a brown colour. When a little of it was dissolved in nitric acid, and the solution evaporated to dryness, no red residue was formed, as is the case with uric acid, but a yellow one; whence Marcet derived the name ξανθος, yellow. Afterwards Stromeyer found that a large stone, which Langenbeck had cut a country-boy for at the hospital at Gottingen, consisted of the same substance. Although Marcet had given a description of this new body, yet we owe the principal part of what we know about it to an inquiry which was instituted by Liebig and Woehler on a portion of the abovementioned stone, which Langenbeck had removed.

The alteration in the name which is here given is grounded on an analytical combustion of this body by these chemists.

The surface of this stone is partly light brown, smooth, and shining, partly whitish, soft, and earthy. When broken it appears of a brown flesh colour: it consists of concentric and easily-separated layers. It has no crystalline or fibrous appearance. By friction it becomes polished with a waxy lustre, and it has about the same degree of hardness as stones which consist of uric acid. Its nucleus consisted of the same substance. In nitric acid it was soluble when heated, without the least evolution of gas, and the solution left, when evaporated in a water bath, a yellow residue, which did not become red either when more strongly heated or when exposed to the vapour of ammonia. It did not melt when heated. It is decomposed by dry distillation, by which first hydrocyanic acid, and then a smell like burnt horn is evolved, just as in the smell of the vapour of uric acid. Then carbonate of ammonia is sublimed, and no cyanate of ammonia or urea. It is dissolved by hydrate of potash when it is finely powdered, and gently heated. The solution has a dark brownish yellow colour, with a tinge of green. If carbonic acid is passed into the solution until the potash is perfectly saturated, the uric oxide is precipitated in the form of a white powder free from potash, which, after it is washed and dried, cakes together into pale, hard, yellow masses, which, after rubbing, become of a waxy lustre. The uric oxide has the following properties: it is without smell or taste. It is decomposed by high temperatures, without first melting. It burns without leaving a residue. It is insoluble in water, alcohol, and æther; and soluble in nitric acid, without the evolution of gas, but with more difficulty than uric acid. The remainder, after evaporating the solution, is citron yellow and soluble in water, with a light yellow colour. It consists of the products of the decomposition of the uric oxide.

The solution in nitric acid becomes reddish yellow by perfect saturation with potash, and salmiak precipitates a yellow substance from it. Chloride of soda evolves from the solution in potash a little nitrogen gas, by which the colour becomes in turn blue, brown, and yellow, and then entirely disappears. It is soluble in sulphuric acid, and it is not precipitated by water. Solutions of hydrochloric acid and oxalic acid in water do not dissolve it. It acts on basic salts as an acid, but it is more feeble than carbonic acid, by which it is precipitated from its combinations. The compounds which it forms with potash and ammonia are very soluble in water. The compound with ammonia leaves, when evaporated to dryness, a mass, which is acid uric oxide combined with ammonia. The uric oxide consists, according to the analysis of Liebig and Woehler, of

	Found.	*Atom.*	*Reckoned.*
Carbon,	39·28	10	39·86
Hydrogen,	2·95	4	2·60
Oxygen,	21·42	4	20·82
Nitrogen,	36·35	4	36·72

According to which, it differs from uric acid in containing two atoms less oxygen. Hence the name of uric oxide, and it $= C_{10}H_4N_4O_4$. It must be remarked, however, that so long as its atomic weight is undetermined by experiment, and so long as it is unknown whether it contains water chemically combined with it, which is very possible, it cannot be considered as decided that it is a lower degree of oxydation of the same radical as is contained in uric acid, however probable it may otherwise be. As uric oxide, its atomic weight should be 962·216, and its saturating capacity 10·41. It is distinguished from uric acid by the following properties: first, by its more difficult solubility in nitric acid, and by the yellow residue which remains on evaporating the solution, which does not become purple red with ammonia, but of a darker yellow; and by the solution in sulphuric acid not being precipitated on the addition of water, whilst only a little water is required in order to precipitate the uric acid from its solution. It is also distinguished by a readier solubility in caustic potash and caustic ammonia.

The solution in potash is not precipitated on the addition of salmiak; but by long-continued evaporation, acid uric oxide combined with ammonia is thrown down in the form of a powder. The uric acid is, on the contrary, precipitated by salmiak. Carbonic acid precipitates both from a concentrated solution in potash, but the precipitated uric acid is soluble in lukewarm water, although with some difficulty. The uric oxide, on the contrary, is insoluble in it. In a dilute solution of carbonate of potash the uric acid is dissolved, but the uric oxide is not soluble in it. By this they can be separated from one another whenever they may occur together. (On this account Professor Liebig, in Turner's Chemistry, directs that they should be dissolved in a solution of potash, and carbonic acid in small quantity then passed into the solution.)

I have frequently found, when physicians have desired an examination of gravel which had been passed, that though externally it was in every respect like uric acid, yet that it dissolved with great difficulty in nitric acid; and the solution after evaporation left a yellow residue, which, when heated, assumed no red colour, and occasionally became a little or not at all red in the vapour of ammonia. This gravel was also soluble in caustic potash; but I have always had too little to be able perfectly to satisfy myself that it really was uric oxide. Meanwhile it is clear, that the uric oxide must occasionally occur as gravel.

Jackson has declared, that he found uric oxide dissolved in the urine of a person who, after an injury of the back, was attacked with diabetes. The substance which he took for uric oxide was deposited of a grey colour when the urine cooled, it reddened litmus paper, and was a little soluble in warm water, and perfectly so in nitric acid, out of which it was again precipitated by carbonate of potash. These re-actions do not, however, appear to justify the assumption, that it was uric oxide.

6th. Cystin. This substance was discovered in calculi by Wollaston, who named it cystic oxide, because it was dissolved as well by acids as by alkalies, and in that respect resembled some metallic oxides. But neither can the name oxide be properly received as a distinction for an organic body, for, with few exceptions, all organic bodies are oxides; nor can the reasons which are given for this name be considered as sufficient. On this account, I have allowed myself to differ from the proposal of this distinguished man as regards the name of this body.

In those calculi which consist of cystin, it forms a dirty yellow, transparent, irregular, crystalline mass; but it can be obtained in pure crystals when dissolved in potash, and acetic acid is added to the fluid when boiling hot. Then the cystin, by slow cooling, separates in six-sided, colourless, transparent scales. It can also be obtained in crystals, if its solution in caustic ammonia is left to evaporate. The scales fall then thicker, and may be considered as regular six-sided prisms.

Cystin has neither an acid nor alkaline re-action. When heated it does not melt. It takes fire with a bluish flame, giving off a sharply acid smell, which at a distance resembles that of cyanogen; but, however, it is so characteristic, that cystin may be thereby recognized. By dry distillation it gives a stinking oil, an ammoniacal water, and a porous, spongy coal. It is almost entirely insoluble in water, but soluble in alcohol. It is dissolved by weak sulphuric acid, nitric acid, phosphoric acid, oxalic acid, and hydrochloric acid; and if the acids are saturated with it, and the solutions are evaporated at a gentle heat, a salt-like compound of cystin with the acid is separated in diverging crystalline needles, which taste acid and are not very durable. So that, for example, hydrochloric acid is driven off from its combination with cystin even at 365°, and the cystin remains behind blackened. The cystin is destroyed when boiled with an excess of nitric acid, and it is changed into a dark brown (and not red) mass, which remains behind when the acid is evaporated.

With acetic, tartaric, and citric acids, the cystin does not combine. It is dissolved by caustic, carbonated and bicarbonated potash, and soda. Caustic ammonia dissolves it, but the carbonate does not. The compound with potash and soda crystallizes on evaporation in granular crystals; that with ammonia becomes decomposed, and leaves pure cystin behind. From its combinations with acids, it is best precipitated by carbonate of ammonia, and from alkalies by acetic acid.

Cystin has an extraordinary composition. It contains 25½ per cent. of sulphur. It was first analyzed by Prout, who determined its composition rightly in respect to the carbon, hydrogen, and nitrogen, but the sulphur escaped him, and he put down the whole loss to oxygen, in which the sulphur is comprehended. Baudrimont discovered and determined the quantity of sulphur in it. This occasioned a new analysis, under Liebig's direction, by Thaulow; the result of which I put down here with that of Prout's.

	Prout.	*Thaulow.*	*Atom.*	*Reckoned.*
Carbon,	29·88	30·01	6	30·31
Hydrogen,	5·12	5·10	6	4·94
Nitrogen,	11·85	11·60	1	11·70
Sulphur, }	53 15	25·51	2	26·58
Oxygen, }		28·38	4	26·47

Marchand found exactly the same amount of sulphur as Thaulow, and the same quantity of nitrogen as both the other chemists. The calculated result differs, however, in containing one per cent. more sulphur than is found by experiment. No conjecture can be formed as to the mode in which it must be considered as composed, for all control is wanting over the probability of the view which may be taken, as long as the capacity of saturation of the cystin is undetermined by experiment.

Lassaigne has described a body which he found in the bladder of a dog, and which he considered as cystin; but the composition of it as given by him differs so much from that of cystin, that it can scarcely be believed that the substance which he examined really was cystin. He says of it, that its solution in ammonia, after evaporation, separated in transparent scales, and the solution in lime water in granules. Syrupy compounds were formed with sulphuric and phosphoric acids, and with nitric, oxalic, and hydrochloric acids, the compounds which were obtained shot out in needles. The sulphate compound contained 0·896 of its weight of this body, which was supposed to be cystin. The nitrate 0·969; the oxalate, 0·78; and the hydrochloric acid compound, 0·947. These numbers do not agree with the capacity of saturation which these acids possess. Lassaigne found this substance to be composed of

Carbon,	36·2
Hydrogen,	12·8
Nitrogen,	34·0
Oxygen,	17·0

This analysis differs so widely from the previous one, that it cannot be supposed that Lassaigne analyzed cystin.

Those stones which consist of cystin do not contain any thing else, at least so far as is as yet known. Their colour is yellowish, their surface smooth, with a crystalline appearance. The fracture shews a concretion of small crystals shining like wax, with rounded angles. They are recognized by their behaviour on platinum foil before the blowpipe, and also by their solubility both in caustic ammonia and in hydrochloric acid, and by the form of the crystals which remain on evaporation of the ammoniacal solution. Since Wollaston's description, cystin has been found by Marcet, Stromeyer, Buchner, Robert, Walchner, and Taylor; the last found in the collection at St. Bartholomew's Hospital two large stones of cystin among 129. The largest of the two weighed 720 grains." (I also found a calculus of this substance in the collection at University College, London, which weighed, after great loss by sawing, &c., above 850 grains. In this, and in one at St. Bartholomew's, a small quantity of the phosphates exist; and oxalate of lime has been found with cystin in a calculus at Guy's Hospital.

Liebig gives the following test. The calculus is dissolved in a strong solution of caustic potash, and to the solution is added so much of a solution of acetate of lead, that all the oxide of lead is retained in solution. When this mixture is boiled, a black precipitate of sulphuret of lead is formed, which gives to the liquid the aspect of ink; abundance of ammonia is also disengaged, and the alkaline fluid is found to contain, among other products, oxalic acid.)

7th. "Phosphate of lime occurs seldom alone and in *the neutral state.* As yet, Wollaston is the only one who has found a urinary concretion of it. According to his description, its surface is light brown, and polished. After it is sawed through, regular layers, lying one on another, are seen, so that the stone may be divided into concentric cups. The fracture across each lamella is striped, and appears to consist of parallel fibres, which pass from the convex to the concave side, and mark the crystallization. The earthy salt is combined in it with an animal matter, which is probably the same which is precipitated with phosphate of lime from urine out of the body. When heated, it becomes a coal, smelling like burnt horn; afterwards it burns white, and at last melts. This last circumstance distinguishes the neutral phosphate of lime from the basic or common bone earth; but in this, great care must be taken that this property of melting does not come from phosphate of magnesia being mixed with it. The powdered calculus dissolves in nitric or hydrochloric acids much easier than the powder of bone earth calculi.

8th. Phosphate of ammonia and magnesia is seldom found entirely alone in calculi; but it not unfrequently forms the greater part. Such stones are then almost always white, and their surface uneven and covered with small shining crystals. They have no lamellated structure, are easily broken and rubbed to powder, and feel coarse. In some few cases such stones have been found hard, semitransparent, and, when broken, crystalline. These stones are dissolved easily by acids, and are precipitated by alkalies, with the ordinary characteristics of salts. Caustic potash disengages ammonia, and extracts the phosphoric acid, whilst the magnesia remains behind undissolved. Heated on platinum foil, they give off ammonia, and blacken, in consequence of the animal matter which they contain; they then become grey, and at last melt into an enamel, which, when mixed with a little nitrate of cobalt before melting, gives a red-coloured button.

9th. Basic phosphate of lime (bone earth) and phosphate of ammonia and magnesia mixed together make, next to uric acid, the most common constituent of urinary calculi. Its formation presupposes that the urine is alkaline, or at least neutral. Such calculi are white, chalky, and earthy, frequently very large, and have sometimes shining crystals of phosphate of ammonia and magnesia in small holes: they seldom appear in the inner layers. By their readily fusing before the blowpipe, they are easily recognized, and this induced Wollaston to name them fusible: when heated, they blacken and evolve ammonia before they melt. Dilute acetic acid dissolves out the magnesian salt, and leaves the greater part of the lime salt behind. They are easily dissolved by hydrochloric acid. If the solution is rendered as nearly as possible neutral, then oxalate of ammonia will precipitate the lime, and afterwards, by the addition of ammonia, the phosphate of ammonia and magnesia will be precipitated.

In these calculi the relative quantity of both salts is variable. Excessive quantities of the salt of lime hinder the fusibility so much as to render them infusible. If the magnesia salt is in excess, they are more difficult to fuse, but not infusible. Sometimes they contain urate of lime, which is discovered by treating them with caustic potash, filtering the solution, and adding an excess of hydrochloric acid, by which the uric acid is precipitated.

These constituents of urinary calculi are ordinarily contained in the urine. We will now consider some others which, in a perfect state of health, are not present therein.

10th. Carbonate of lime is a rare constituent of stone in man, but the most frequent in graminivorous animals. Concretions of this salt in man are white or grey, and at times yellow, brown, or red. The carbonate of lime is always combined with an animal matter, which is the cause of the colour, and this, when heated, burns with the smell of burnt horn. The formation of this stone presupposes that the urine is alkaline, and that the usual phosphatic salts are absent. These stones are easily known by their effervescence with hydrochloric acid, in which they dissolve, and after they are heated to a red heat by a strong fire, they leave caustic lime.

Proust found a stone which consisted only of carbonate of lime, with a small trace of urate of lime. Another hard stone, which weighed seven ounces, consisted, according to him, of 0·8 carbonate of lime, 0·2 basic phosphate of lime, without a trace of uric acid. According to Proust, this constituent of calculi has been found by Cooper, Prout, Smith, and lately by Fromherz, who found by analysis 0·91 carbonate of lime, 0·03 phosphate of lime, and 0·04 albumen and brown colouring matter, with a trace of oxide of iron. In the interior this stone had a little bit of quartz, as a nucleus."

(Dr. Prout has mentioned, that he finds the small quantity of carbonate of lime which sometimes exists in phosphatic calculi increases by being kept for a considerable time. This may be caused by slight quantities of some organic acid, combined with the lime, becoming oxydised by exposure to the air when in contact with mucus of the calculus, and thus becoming carbonate; as, for instance, lactate of lime.)

11th. "Carbonate of magnesia. It is highly probable that this always occurs in stones consisting of carbonate of lime, since it is easily overlooked, unless purposely looked for. Lindbergson examined a urinary concretion, which consisted of urate of soda 9·77, basic phosphate of lime 34·71, phosphate of ammonia and magnesia 38·35, carbonate of lime 3·14, carbonate of magnesia 2·55, albumen 6·87, water and loss 4·58.

12th. Oxalate of lime is a somewhat frequent constituent of urinary calculi, especially in children. Such stones have usually an uneven surface, similar to a mulberry, on which account they have been called mulberry calculi. They have a dark blackish green, or brown colour, which Marcet supposes to be derived from blood which occurs from time to time in consequence of irritation of the urinary passages by its sharp-angled tubercles. I have even seen cases in which the urine became bloody in consequence of the descent of such a stone from the pelvis of the kidney. Sometimes such stones are very small, and of a lighter colour, similar to hemp-seeds. I have even seen them white and light-yellow, forming a strong compact collection of sharp-angled crystals. The dark ones, however, seem to be coloured, not so much from blood, as rather from the same animal matter which is thrown down with the insoluble salts of lime from the urine. The quantity of this substance is by no means small, yet I do not know that it has ever been determined, although it is easily done; for the quantity of oxalic acid can be calculated from the quantity of lime which remains after it is heated to a red heat.

If a dark-coloured stone of oxalate of lime is heated before the blowpipe on platinum-foil, it swells out, burns, smells of burnt horn, and leaves caustic lime after being strongly heated in a good fire. The lime, when moistened with a drop of water, re-acts strongly alkaline, without being dissolved. When the powder of such stones is digested in hydrochloric acid, it is dissolved, and the salt is again deposited, on evaporation, in small crystals.

Caustic potash extracts from it an animal substance, without acting on the salt itself; but it is decomposed by the carbonate of potash, leaving the carbonate of lime: in this the animal matter follows the acid, and combines with the oxalate of potash.

It is not known how the oxalic acid comes into the urine, although it is so important in order to know how to avoid the circumstances which occasion its formation. So much is known, that excessive or daily use of acid vegetables, as, for example, oxalis acetosella (the wood sorrel), and rumex acetosella (the common sorrel), which contain free oxalic acid, or its acid salts, occasion the formation of gravel of oxalate of lime, which again ceases as soon as these vegetables are abstained from; but other unknown circumstances also, in which not the least injury to the health is perceived, appear to participate in producing it.

13th. Organic substances. Fibrin, albumen, casein, and mucus of the bladder, can form a part of most urinary concretions, without its being possible, by means of chemical analysis, to determine which of these animal matters was originally contained in them. Among these, Marcet has found a urinary concretion which consists almost entirely of one of these substances. It looked like yellow wax, and was of about the same consistence. Its surface was uneven, without being rough, and its section was radiated and fibrous, and it was somewhat elastic.

It burnt with a smell like horn, leaving behind a porous coal. In water, alcohol, and hydrochloric acid, it was insoluble, but soluble in caustic potash, and precipitated on the addition of hydrochloric acid. Nitric acid dissolved it, but with greater difficulty than uric acid or cystin. With acetic acid it first swelled up, and afterwards dissolved by boiling, and the solution was like fibrin precipitated by ferroprussiate of potash. Hence Marcet concluded that this stone consisted of fibrin; but the solubility in nitric acid does not belong either to fibrin or albumen.

Morin found, by analysis of a stone taken from a man sixty-one years old, an organic matter in combination with phosphate of lime. In the nucleus of the stone it amounted only to 10 per cent.; but in the second layer 18, and in the third layer to 70 per cent. of the weight of the stone. Alcohol dissolved out some fat. In acetic acid it was little soluble: something more in nitric acid. In caustic potash it swelled up, became slimy, and in part dissolved. This animal matter which was obtained by Marcet, and that by Morin, have all the properties of hardened mucus of the bladder. From what I have already said on this subject, it will be seen that it possesses the chemical properties of a body containing protein; but it shews the characteristic difference of being soluble in nitric acid, which property is absent in other protein compounds." (There is a small calculus of Sir B. Brodie's in the museum of St. George's Hospital, which Dr. Prout considers to consist of fibrin.)

"Scharling has examined a urinary concretion preserved in the museum at Copenhagen, which weighed 255 grains, and was taken from the bladder of a man after death. It has a fibrous texture, which it retained when treated with water; when rubbed in a mortar, however, when dry it was brittle, and easily powdered. Æther and alcohol dissolved out fat, and potash a protein substance, which was insoluble in nitric acid. It appeared to be composed of 55·36 per cent. fibrin or albumen, and 44·64 per cent. bone earth. Many chemists, by treating the powder of dried urinary concretions with æther and alcohol, have found that these solvents have taken up small quantities of fat from human calculi, and both fat and resinous substances from those of animals, which probably are altered vegetable substances from the food, which are thrown out by the urine.

14th. Silica is the last constituent to be mentioned; it was found by Fourcroy and Vauquelin in two stones out of 600. One of these had but very little silica, and the other had a nucleus like oxalate of lime, which consisted of 0·66 silica and 0·34 animal matter. When this was burnt, the silica remained, and was recognized by its chemical properties. A third case is related by Venables, who found silica in the gravel of a woman;" (and in a case described by Dr. Yellowly, in the Philosophical Transactions, the silica was mixed with oxalate of lime, and uric acid.)

"The urinary concretions have been divided into different classes and orders, according as they consist of one substance, or of many mixed with one another, or of many with alternating layers; but as such mixture and alternation is not determined by constant circumstances, but arises in innumerable ways, according as different circumstances occur, as, for instance, with the state of health of the individual in other respects, the mode of life, diet, and the use of medicines, on this account I do not enter into such divisions. I only remark, that this mixture of various substances, and the variation in the composition of different layers in one and the same calculus, is generally present and occurs very frequently.

English physicians, who have opportunities of seeing many and great collections of urinary concretions, have taken pains to make out their relative frequency of occurrence. Hence it has generally appeared, that in England those stones are most common which consist chiefly of uric acid. Next to this comes fusible calculus, more especially if one adds those cases in which this earthy salt occurs intermixed or forming the largest part. Then follow those which consist of varying layers of uric acid, phosphate and oxalate of lime. For example, there were among 1000 stones,

372 of uric acid alone, or mixed with small quantities of urate of ammonia, and oxalate or phosphate of lime.
253 of phosphatic earths (fusible).
233 of varying layers of uric acid, oxalate of lime, and phosphatic earth.
142 oxalate of lime.

The stones which rarely occur, as carbonate of lime, cystin, and silica, cannot be taken into any reckoning like this. Moreover, the relative proportion varies in different lands, according to different climates, different prevailing food, work, and the habits of the people. So Rapp found, for example, among 81 stones at Wurtemburg,

22 oxalate of lime alone.
34 in which oxalate of lime was mixed with other substances, so that there were 56 oxalate of lime therefore in the whole.
16 uric acid altogether, namely, 7 uric acid by itself, and 9 uric acid mixed with phosphatic salts.
7 fusible.
1 urate of ammonia.
1 phosphatic earth, with 13 per cent. carbonate of lime."

Perhaps a general statement of the causes of the different kinds of calculi, in accordance with the views which I have set forth in the First Part, may be given thus: When the health is good, and the oxygen acts perfectly, no deposit would take place; when the oxygen acts in a less degree, a deposit of oxalate of lime occurs; when still less, urate of ammonia or uric acid. If the health becomes bad, or the irritation from the stone causes the urine to become alkaline, the phosphates are precipitated; and if the oxygen is still further prevented acting, the phosphoric acid would be formed in exceedingly small quantities, and carbonate of lime would be deposited.

CHAPTER II.

ON THE REMOVAL OF THE STONE.

There are but three possible ways of removing a calculus from the bladder: 1st, whole; 2ndly, in parts, the chemical nature of the stone being unchanged; 3rdly, in parts, the chemical nature being changed. The first method only was thought practicable until lately, when the second was attempted, and it is now very generally employed. The last mode has rarely succeeded; it has, therefore, been much neglected, and is usually passed over unnoticed, because it belongs more to the chemist than to the surgeon. On this account, I shall merely refer to surgical books for all information on the two first modes, and proceed at once to the last—to the solution of calculi.

This has been attempted in two ways: 1st, by solvents taken as medicines; and, 2ndly, as injections.

The medicines which have been as yet used are chiefly alkalies, in some form or other, which cannot act as solvents until they have rendered the urine slightly, though decidedly, alkaline; and as soon as this happens, the phosphates are usually precipitated; so that, however much such medicines in moderation may hinder the increase of a calculus, still, when given in excess, in order to dissolve that which has been deposited, they only change the material of which the fresh deposit consists; the calculus continuing to increase by the addition of the phosphates instead of uric acid or the urates. The benefit which has been derived from these medicines has been exaggerated by those who have held them forth to the world as the means of cure. That they should have given an impartial statement of the effect of these medicines, could not be expected.

In Sir A. Cooper's Lectures on Surgery, 8th Edit. p. 306, there is a recommendation to give alkalies (soda), in order to cause a deposit of the phosphates, to coat the surface of the stone, which may cause less irritation of the bladder; and this is certainly the usual action of alkalies, when taken in excess. M. Petit has asserted, indeed, that by taking the Vechy waters, which contain bicarbonate of soda, no phosphates are produced; but, excepting in cases of the greatest weakness, phosphates must be formed, however much they may appear to be diminished in consequence of the excess of water which may be taken.

Moreover, M. Pelouze, one of the best chemists in Europe, having been appointed to make a report, has given an opinion different from that of M. Petit; the particulars of this will be found in his Report to the Academie des Sciences. In Germany, borax has been long used as a medicinal solvent; and lately in this country, Mr. Ure has suggested the use of hippuric acid; but according to Mr. Garrod's paper in the Transactions of the Chemical Society, and M. Keller's in the Appendix to Liebig's Animal Chemistry, but little benefit can be expected from its use, excepting that which may be derived from a slightly stimulant diuretic. Any solvent which passes through the system must be used so long that it will produce a bad effect either by acting on the constitution, or by causing a deposit of the phosphates; and consequently, it is very improbable that calculi will be ever removed by medicines, though these may assist in the cure by hindering any fresh deposit.

2ndly. On the subject of injections I can as yet offer but little, excepting the history of what has been done, and some remarks which may occur to me; and though the means which have been hitherto used have been generally so insufficient to accomplish the object, that the idea of effecting it with certainty is thought by most to be absurd, still the result is worthy of the utmost efforts of the chemist to obtain.

Berzelius, in the last German edition of his Handbook, says: " The attempts which have been made to dissolve concretions in the bladder have not succeeded as we might have expected. However, I am perfectly convinced that they have not been often enough repeated to enable us to find out and remedy those obstacles which we are unable to foresee, and which frequently increase the difficulties of their application."

The following tabular view enables us to see what has been hitherto attempted, and with what success. In the words of the British and Foreign Quarterly Review, for Oct. 1841: "So much has already been done as to hold out every inducement to perseverance, and perseverance must of necessity be crowned with success in a certain proportion of cases."

HISTORY OF ATTEMPTS WITH REGARD TO THE SOLUTION OF CALCULI BY INJECTIONS.

Year.	Patient.	Injection.	Quantity and Time.	Result.	Authority.
1745	Boy, 10 years old.	Oyster shell lime-water with a little starch.	2 ounces. 3 hours.	"Without any pain or uneasiness."	Whytt on Lime Water, p. 130.
1746	Dog.	Lime-water mixed with soap leys, from 15 to 20 drops to each ounce of lime-water.	unknown. unknown. Twice daily for a month.	"Without any pain or ill effect."	Langrish, "Physical Experiments upon Brutes."
Before 1752	Dog.	Warm water.	3 gallons. 4 hours.	"Without the least harm or inconvenience.	Hales's Statics. Vol. 2, p. 212.
1752	Man.	Lime water.	5 ounces. "Some time."	"No uneasiness."	Whytt, p. 134.
1753	Man.	Lime water.	above 5 ounces. unknown. Twice daily for 10 weeks.	"No relic of stone was left."	Butter, a Method of Cure for Stone, chiefly by Injection, 12mo. Edinburgh, 1754.
Before 1775		A weak ley of alkali with fat and some opium.	unknown.	An Englishman in Arabia Petrea has frequently seen a calculus dissolved in the bladder by this injection.	Edinburgh Medical Commentaries, Vol. iii. p. 333.

Before 1806	Man.	A solution of caustic potash which hardly produced a feeling of warmth in the mouth.	3 to 6 ounces at 98 F. $1\frac{1}{2}$ hour. Twice daily.	Perfect cure.	Hufeland's Journal. Band xxv. Part 2, p. 144. Also in British and Foreign Quarterly, April, 1842.
Before 1819	Man.	Twenty-three drops of muriatic acid in 4 oz. of water.	often an hour.	"Without producing inconvenience."	Marcet, p. 189.
Before 1825	Man.	Mucilage water with a little sulphuric acid.	about 25 pints daily. unknown.	Partial success.	M. Leroy, d'Etiolles, Exposé des divers Procédés employés jusqu' à ce jour pour guérir de la Pierre. 8vo. Paris, 1825.
1831	Man.	2 to $2\frac{1}{2}$ minims of nitric acid to each ounce of distilled water.	unknown. 15 to 30 minutes. Every two or three days.	A phosphatic calculus was dissolved.	Brodie, London Medical Gazette, June, 1831; and Lectures, p. 298, Edit. 1842.
Before 1842	Man.	Water, containing from $\frac{4}{100}$ths to $\frac{5}{100}$ths of its weight of nitric acid.	unknown.	Fragments of a phosphatic calculus were dissolved.	Comptes Rendus, 21st of March, 1842, Tom. xiv. No. 12.
Before 1842	Man.	346 grains of bicarbonate of soda to the pint of water.	in all 250 pints of water. unknown.	Fragments of a uric acid calculus became so friable, that very slight pressure was sufficient to break them.	Comptes Rendus, 21st of March, 1842, Tom. xiv. No. 12.

In addition to the foregoing table, Berzelius recommends a lukewarm solution of one part of carbonate of potash, and ninety to a hundred parts water mixed with a little mucilage; and in cases where the stone consists of uric acid, he suggests that a solution of borax should be tried, by which a urate of soda and biborate of soda would be formed.

Dr. Marcet states, p. 189, that in general, alkalies cause less irritation than acids.

Dr. Arnott appears to have re-introduced the double catheter, which Hales invented and Gruithuisen recommended; and that which Sir B. Brodie used in his successful case consisted of two small catheters united together side by side, while Dr. Arnott's was a small catheter within a large one, which he thinks will allow mucus to pass with the greatest ease. Both Arnott and Brodie appear to have invented an apparatus for keeping up a continued stream of the solvent, though neither used it. About the year 1825, M. J. Cloquet used a continued stream of water, at a temperature between 90° and 100° F., which caused so little inconvenience that, according to Mr. Belinaye on Calculus, p. 60, " it may be employed during the patient's sleep."

It seems then quite possible, from Hales' experiment on the dog, and M. Cloquet's on man, that an unlimited quantity may be injected into the bladder.

The latest experiments which have been made are those of M. Pelouze, in the Comptes Rendus of the Academy of Sciences, 21st March, 1842, Tom. xiv. No. 12, he having been appointed, with M. Guy Lussac, to make a report on many communications of M. le Docteur Leroy d'Etiolles, relative to the solution of urinary calculi. He says:— "The experiments made in our presence were of two kinds: first, in the laboratory; secondly, on patients; occupying two years. We found the bicarbonated alkalies more efficacious than the carbonated, but even their action was very feeble; and in some fragments which were exposed to the waters at Vichy, though the solution was very slow, yet it was more rapid than in solutions of alkaline carbonates or bicarbonates, probably from the mechanical action of carbonic acid gas.

"Pieces of different kinds of calculi were left for a year in solutions of carbonate and bicarbonate of potash and soda, of the strength of from 230 to 460 grains to the pint of water, at the temperature of the laboratory, and occasionally at from 96 to 104 F.; none of them were dissolved; each appeared to retain its original volume, and the actual loss varied from $\frac{1}{4}$ to $\frac{1}{2}$ of their weight.

"Pieces of calculus, weighing from 116 to 230 grains, were exposed during three consecutive months to 500 pints of water, containing $\frac{1}{20}$th of its weight of bicarbonate of soda. Their volumes were not sensibly diminished, but they were become more friable; the actual loss was from $\frac{1}{10}$th to $\frac{6}{10}$ths. We substituted the borate of soda and of potash for the carbonate, and in other experiments, nitric and hydrochloric acids were used, but the same difficulty occurred, though it was something less in the case of the borax.

"2ndly. We made experiments on patients, the greatest number of whom tried, for a longer or shorter time, the solvent action of mineral waters, or those of bicarbonate of potash or soda. We conclude that it is quite certain that the use of alkalies, in certain circumstances, determine a deposit of calculus in the bladder.

"No attempt, by direct injection, was made on an entire calculus, but patients were taken in whom pieces remained after the operation of lithotrity had been performed. Carbonated and bicarbonated alkalies, caustic alkalies, borax, hydrochloric acid, and nitric acid, were dissolved in distilled water, and injected, at a temperature from 96 to 104 F., with a double catheter; from 25 to 250 pints were used. By some, no pain or fatigue was experienced; with the greatest number, the bladder became irritable and the injections were stopped. Once only did the pieces of calculus disappear, being dissolved in water containing from $\frac{4}{100}$ to $\frac{5}{100}$ of its weight of nitric acid. The calculus consisted of phosphate of lime and phosphate of ammonia and magnesia.

"In many cases we remarked a considerable diminution in the cohesion of the calculus. In one patient, whose bladder was not irritable, we employed a strong injection of alkaline water, containing 346 grains of bicarbonate of soda to the pint of water. We knew that the calculus was uric acid; we passed through the bladder 250 pints of water, holding in solution 59 ounces, 7 drachms, and 3 grains of bicarbonate; after this enormous mass of water the volume was not sensibly diminished; but instead of remaining excessively hard, as they were at first, they became so friable that very slight pressure was sufficient to break them. In the greater part of the other experiments the injections could not be continued, and the fragments lost nothing of their hardness or volume.

"In conclusion, we have been very little satisfied with our attempts at solution by means of injection. The borax, which has lately been recommended as a more energetic solvent than the alkaline carbonates, gave us no better results than these latter salts did; and the same may be said of the other agents which are mentioned above. Benzoic acid, with a little borax and alkaline carbonate, was tried as a medicine: the results were negative; we found only a small quantity of hippuric acid in the urine. We consider M. Leroy d'Etiolles to have established the following conclusions.

"1st. That certain agents exercise a destructive action on urinary calculi, though they act less on the principles which form them, than on the animal matter which unites them. This action is very slow, even out of the bladder.

"2ndly. That a cure is not likely to be effected by drinking and baths.

"3rdly. Direct injection is more powerful, but success is problematic; and the chances of inflammation are not sufficiently compensated, as in lithotrity, by a rapid destruction of the stone.

"4thly. That though the combination of lithotrity with injection increases the probability of success by increasing the surface—still, after the first crushing, the chief difficulties are surmounted, and it will be wisest not to change the mode of cure.

"We hope that these observations, by shewing the difficulties connected with solution, may be far from discouraging attempts, the success of which is so desirable; and that they may call forth new researches on this important question. M. D'Etiolles was requested to continue his researches."

I have given the above extract at considerable length, because it is only by looking at what has been done, and at the difficulties which have occurred to others, that we can attain to success. This account shews, that as yet, for the most part, but little has been accomplished; but the discoveries of chemistry are by no means ended; and though it is improbable that any single substance will ever be discovered which will dissolve all kinds of calculi, yet new applications may at some future time prevail.

At the last meeting of the British Association, Mr. Mercer stated, that on mixing oxalic acid and nitric acid with a little water, and raising the temperature to 130 F., no action ensued; but if a small quantity of protosalt of manganese was added, the decomposition immediately commenced. The nitric acid was converted into nitrous acid, whilst the oxalic acid passes into carbonic acid. Oxalic acid differs from oxalate of lime, and nitric acid with a little water could not be borne in the bladder; but I have mentioned this only to shew that new means of effecting chemical changes may be discovered, and some of these may enable us to change the oxalic acid into a substance which would be as easily removed as carbonate of lime.

With regard to uric acid, its peculiar property of undergoing changes is so remarkable, that most probably the means of effecting a change in such calculi when in the bladder will be first discovered.

At present, then, but little can be effected by injection in calculous cases, excepting where there is sufficient evidence that the calculus consists of phosphates, of cystin, or of carbonate of lime. The case recorded by Sir B. Brodie and that by M. Pelouze put the question of the phosphates beyond all doubt, whilst the far greater solubility of cystin or carbonate of lime in the same menstruum renders success with such calculi even more certain.

If, then, after a calculus has been once caught and crushed (which is neither painful nor dangerous, the operation usually becoming so from frequent repetition), the pieces which are passed are found to consist of the phosphates, of cystin, or, which is extremely improbable, of carbonate of lime, then there can be no question that the most dilute solution of hydrochloric or nitric acids may effect a cure, if ejected in large quantities, without danger or suffering. Such calculi are much more rare than those of uric acid or oxalate of lime, and therefore it is as yet far easier to prevent the formation of a calculus, by guarding against the uric acid diathesis, than it is to effect a cure.

APPENDIX.

APPENDIX.

The following account of the state in which the uric acid occurs in the urine is from the German edition of Berzelius's Hand-Book of Chemistry :—

" Warm urine contains much more uric acid in solution than an equal weight of warm water can dissolve. On this account, Prout assumed that the uric acid was contained in the urine as urate of ammonia, which on cooling was decomposed by the excess of free acid. It is not easy to say how so complex a fluid as the urine holds the matters, which are difficult of solution, dissolved. It is possible that the uric acid, at the temperature of the body, preserves an equilibrium with the phosphoric and lactic acids in their acid salts; but it is not probable. We know, moreover, for example, that iodine is dissolved in water which contains common salt, or salmiak, in greater quantities than in pure water, although we know of no combination of iodine with these salts. However it may be, the uric acid which is precipitated from urine, on cooling, is free acid, with only such a small trace of ammonia and soda, that it is not worthy of notice; more especially, provided the mucus is separated before the urine cools. The precipitate is at first powdery, and grey as clay; but it collects together more and more, and becomes pale pink, and when dried, crystalline, and like fine scales. The finer the scales are, the purer the acid is; and, on the other hand, the more distinctly crystals can be distinguished, the more impurity there is from bases. The fine scaly precipitate dissolves in caustic potash, without the fluid smelling of ammonia; but a trace of ammonia can be discovered, by holding a glass rod moistened with hydrochloric acid over it, and, when burnt on platinum, a trace of carbonate of soda remains. If, on the contrary, such sediment is crystalline, and consists of small, reddish, angular crystals, it will evolve ammonia in considerable quantity, when treated with potash; and the fluid, which at the beginning was red, becomes, after a time, yellow. It also leaves behind more ash when burnt on platinum.

"Urate of ammonia is seldom precipitated from urine that has been left to cool. When it is, it sinks only slowly, and again dissolves if we try to wash it out with water. Most commonly it crystallizes in from twenty-four to thirty-six hours, out of urine which deposits no sediment; or it happens that the previously-precipitated flaky acid, when it remains in urine which has become alkaline, is changed into large reddish crystals of urate of ammonia. The mucus in which the uric acid is deposited plays so important a part in the formation of a salt of ammonia, that if, after the urine has become thick, it is filtered, and the deposit washed on a filter, and after that placed under water, the crystallization often takes place in a few hours.

"The deposit from urine which has been filtered when warm retains, after being washed out and dried, its glistening, fine scaly appearance; whilst, on the contrary, that from unfiltered urine, after washing and drying, is markedly crystalline, and contains ammonia. On cooling, all the uric acid is not precipitated from the urine, but a by no means inconsiderable part remains dissolved; and, moreover, it is not every healthy urine which deposits a sediment on cooling, at least not when the air is moderately warm. If filtered urine is evaporated, there remains a grey deposit, which is a mixture of uric acid and phosphate of lime. Uric acid can be precipitated also on the addition of nitric or hydrochloric acids. It is deposited commonly after some time as a powder, or in crystals, according as it has fallen quickly or slowly.

"The uric acid which is precipitated from urine, although it commonly looks greyish as long as it lies in the urine, becomes, however, after being washed, strongly red or brick-coloured. This colour proceeds from a foreign colouring matter combined with the acid. In intermittent fever, this red colouring matter is considerably increased. The urine deposits then, at each febrile accession, a deep brick-coloured, sometimes rose-red, and even beautiful carmine, sediment. This colouring matter was first examined by Proust, who at first considered it as a peculiar acid, which he called rosaic; but afterwards he remarked that it was nothing else but a combination of uric acid, with a peculiar extractive-like red colouring matter.

"If the red precipitate from the urine of those who are ill with fever is treated with boiling water, or boiling alcohol, the colouring matter is extracted; on evaporating the alcoholic solution, a scarlet-red powder is left behind, which has neither taste nor smell. On this subject Vogel states, that the colouring matter extracted with alcohol contains still a portion of uric acid. On burning, it does not smell like burnt horn. By sulphuric acid it is dissolved; the solution is of a rose-red colour, which soon becomes dark red: by the addition of water, the uric acid is precipitated from it unchanged. Sulphuric acid, with three parts of water, extracts the colour, and becomes red; but leaves the uric acid behind. By a solution of sulphurous acid it becomes carmine red. Nitric acid and chlorine change it in the same way as they do pure uric acid. By hydrochloric acid the red colour is altogether destroyed, and changed to yellow. Alkalies dissolve it; the solution soon becomes yellow, and re-acts then exactly like a solution of uric acid in alkali.

"Duvernoy declares, that the red sediment of fever can be procured from ordinary urine, if it is evaporated to $\frac{1}{3}$ or $\frac{1}{4}$, and then mixed with a little nitric acid, and left to stand from 12 to 16 hours, by which it becomes dark red. If then an uric acid salt is added, the uric acid is precipitated red, and alcohol extracts from the precipitate the ordinary red matter. If a solution of the red matter in water is mixed with a solution of acetate of lead, a pale rose-red precipitate is formed. By nitrate of mercury, it becomes, after some hours, green.

"Fromhertz and Gugert, who made experiments on the red sediment of the urine in disease of the liver, obtained a similar result. By long-continued soaking in water, or boiling in alcohol, a red extractive-like colouring matter is taken up, which by alkalies was changed to yellow. Its property of reddening litmus came only from its red colour.

"Prout, on the contrary, attributes the red colour in the sediment of urine to an intermixture of purpurate of ammonia, because the purpuric acid can be artificially produced, by treating uric acid with nitric acid; and Prout found nitric acid, in some state of combination, in the precipitate from feverish urine. He digested such a deposit with nitrate of baryta and water, filtered the solution, precipitated it exactly with sulphate of potash, evaporated it, and obtained from it, after sufficient concentration, crystallized saltpetre. Nitric acid, however, occurs but seldom, and Wurzer found it only once in eleven cases in which he sought it.

"The solubility of the colouring matter in alcohol speaks against the supposition, that this colour comes from purpurate of ammonia, which does not colour alcohol.

It is certain, that if urate of ammonia is mixed with a solution of a purpuric salt and acetic acid (which does not destroy its colour), the uric acid is precipitated of a pale rose-red colour. However, by boiling, alcohol extracts no trace of colouring matter. I made the following experiment: I mixed urine with a purpuric salt and acetic acid, whilst another portion of the same urine was left alone unmixed. Both deposited, as far as colour went, exactly similar sediments, and the alcohol with which both were boiled became yellow coloured, without the addition of the purpuric acid salt having increased the colour of the precipitate in the smallest degree, or appearing to have communicated any of its colour to it, inasmuch as both, after boiling, were yellow.

" The ordinary pale red deposit which is frequently thrown down from the urine of those in health does not appear altogether identical with that from the urine in fever; for water extracts nothing from it, and alcohol which is long boiled with it becomes yellow, and leaves, after evaporation, a dark reddish, yellow, extractive-like substance, which dissolves with difficulty in water, leaving behind the red powdery colouring matter: that which dissolves is urate of soda with a little urate of ammonia. From the red powder, which is soluble in a large quantity of water, a small quantity of alcohol extracts the red colouring matter, and leaves behind a yellow coloured powdery uric acid. The acid, boiled with alcohol, does not become colourless, but yellow, and acetic acid extracts from it a part of the yellow colour."

On this subject, I think it interesting here to mention what Berzelius elsewhere states, that " Landerer found that the colouring matter from red perspiration, which had become collected on flannel under the axilla, in a patient with fever, by boiling with a very dilute solution of potash, could be extracted. The solution then gave with sulphuric acid a red precipitate, which in every respect coincided with the red precipitate from the urine which is wont to be formed in the paroxysm of fever." I have only once seen this red colouring matter, which was also from flannel in the axilla of a patient subject to rheumatism, who had at the same time a red deposit in the urine. It was not soluble in water.

THE END.

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