

alteration of pitch by conduction is that by Dr. Walshe*, who ascribes it to transmission of the vibrations through "varying" media.

- II. "On the frequent occurrence of Phosphate of Lime, in the crystalline form, in Human Urine, and on its pathological importance." By ARTHUR HILL HASSALL, M.D. Lond. Communicated by Dr. SHARPEY, Sec. R.S. Received November 9, 1859.

In 1854 I submitted to the Royal Society a paper "On the frequent occurrence of Indigo in Human Urine." This communication, which was published in the 'Philosophical Transactions,' attracted considerable attention both at home and abroad. The singular fact of the frequent presence of indigo in the urine, first announced by me, has since been amply confirmed by a variety of observers. I have now to place before the Society some investigations in relation to the not uncommon occurrence in human urine of *phosphate of lime*, as a *deposit*, in a well-marked *crystalline* form.

When the earthy phosphates are treated of by writers, in connexion with the urine, they are usually described collectively, and it is seldom that each kind of phosphate is particularized, and yet there are several which may occur either separately or together. The phosphate of ammonia and magnesia, or triple phosphate, is indeed often specified, but rarely is phosphate of lime separately mentioned, and phosphate of magnesia scarcely ever; and yet phosphate of lime is very frequently present as a deposit in urine, much more so, indeed, according to my experience, than the triple phosphate, excluding those cases of the occurrence of that ammoniacal phosphate, arising from the decomposition of the urea of the urine subsequent to its escape from the kidneys. Even in those few cases in which phosphate of lime is specially mentioned, it is described *usually* as mixed up with the other phosphates, and *always* as occurring in the *amorphous* or *granular*, and never in the crystalline state; further, no peculiar importance is attached to it, as contrasted with the magnesian phosphate.

* Disease of the Lungs, Heart, and Aorta. 2nd edition, page 151.

Even one of the most recent writers on the urine gives the following description of the physical characters of deposits of phosphate of lime in urine:—"Deposits of phosphate of lime," he states, "as usually occurring in the urine, and mixed with magnesia, are always white and amorphous, under the microscope appearing in granules, sometimes of a greenish tinge, which exert a refracting action upon light. *Crystallized deposits of this substance have not been observed.*"

I now propose to show, *first*, that there is a crystalline deposit, the crystals composing which will be described hereafter, which does really consist of phosphate of lime; *second*, that it is of frequent occurrence in human urine; and *third*, that it is of greater pathological importance than the deposits of triple phosphate.

I would first remark that I have for years been acquainted with the fact of the occurrence of crystalline phosphate of lime in the urine, and I have referred to it in 'The Lancet' of 1853, and also elsewhere. I should now remark, however, that the statement made by me as to the composition of the crystals, has hitherto been based upon their *qualitative* analysis only, and therefore was not so completely conclusive and satisfactory as could be desired. Until recently I had not made any *quantitative* analyses; these I have since been enabled to perform, and I now furnish the results of the chemical examination of four samples of the deposit.

First Sample.—Filtered from the urine of twenty-four hours; mixed, as ascertained in the first instance by means of the microscope, with a very minute quantity of *triple phosphate*.

Bibasic phosphate of magnesia.....	0·15
Bibasic phosphate of lime.....	1·85
	<hr/>
	2·00

Second Sample.—Filtered from urine after the lapse of a day or two; mixed with a small quantity of *triple phosphate*.

Bibasic phosphate of magnesia.....	0·47
Bibasic phosphate of lime.....	6·18
	<hr/>
	6·65

Third Sample.—From urine of twenty-four hours, after the lapse

of several days. Admixed with much triple phosphate, as shown first by the microscope, and afterwards by the chemical analysis.

Bibasic phosphate of magnesia.	4.30
Bibasic phosphate of lime.	5.41
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	9.71

Fourth Sample.—Separated from six ounces of fresh urine. Deposit very pure.

Bibasic phosphate of lime.	1.96
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No phosphate of magnesia.

Now the admixture of the phosphate of magnesia in the first three samples was due solely to the fact that the phosphate of lime, deposited at first in the pure state, was allowed to remain in the urine until decomposition had commenced, and the phosphate of magnesia and ammonia had, in consequence, become formed. Deposits of phosphate of lime are sometimes contaminated from the same cause with carbonate and oxalate of lime.

These analyses are therefore conclusive as to the composition of this earthy phosphate. In order to show that no error has been committed in them, I here append the process adopted. That the deposit in question really consisted of a *phosphate*, was first repeatedly determined by the action of a solution of nitrate of silver; the crystals when touched with this reagent assumed a bright golden yellow colour. After having been separated and washed in distilled water, the phosphate was ignited to free it from animal matter, urea, &c., and weighed. It was then dissolved in hydrochloric acid; ammonia was added until a permanent precipitate formed; this was redissolved by the addition of acetic acid. First the *lime* was precipitated from the solution by oxalate of ammonia, and afterwards the *magnesia* as follows: chloride of ammonium was added, then ammonia in slight excess, and lastly, phosphate of soda. The oxalate of lime formed was converted into carbonate of lime in the ordinary manner, and the phosphate of ammonia and magnesia into the pyro-phosphate of magnesia; these were then weighed separately, and the amounts of the bibasic phosphate of lime were determined by the usual calculations. The results obtained corresponded very closely with the original weights of the ignited phosphates subjected to analysis. The

analyses, therefore, show that the crystallized phosphate of lime is a tribasic phosphate containing two atoms of lime, and most probably one of water.

Form of the Crystals.

The size, form, and arrangement of the crystals of phosphate of lime, as they occur in human urine, vary greatly, but the peculiarities are in all cases sufficiently characteristic to allow of the ready identification of this phosphate by means of the microscope. The crystals are either single or aggregated, most frequently the latter, forming glomeruli or rosettes, more or less perfect (figs. 1, 2, 3). Sometimes they are small and needle-like, and then they frequently form by their crossing and union at right angles, glomeruli or sphe-rules (fig. 3). Sometimes the crystals are thin and flat, having oblique

Fig. 1.

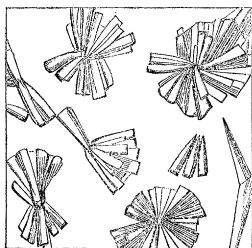


Fig. 2.

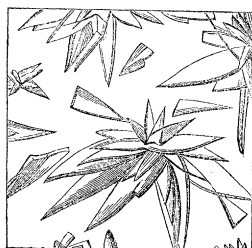


Fig. 3.

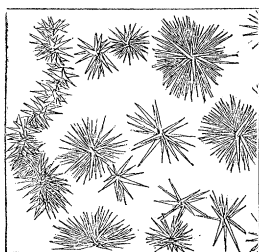
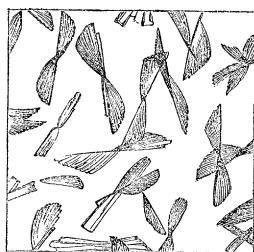


Fig. 4.



or pointed terminations (fig. 2). Very frequently, however, they are thick, and more or less wedge-shaped, and united by their narrow extremities so as to form more or less complete portions of a circle (fig. 1); the free larger ends of the crystals are usually somewhat oblique, and the more perfect crystals present a six-sided facette. I have never yet met with these crystals having both ends perfect, owing, I believe, to the tendency which they have to crystallize from a centre

in rosettes. The principal modifications which I have met with in the size, form, and arrangement of these crystals, are well shown in the eleven drawings which accompany this communication*. When these crystals are kept in the dry state for a long time, they not unfrequently break down and crumble into powder.

The late Dr. Golding Bird, in his work on 'Urinary Deposits,' has given a representation of some crystals which he has denominated "*penniform*," describing them as consisting of a variety of the magnesian phosphate; the crystals figured do, however, undoubtedly represent a modification of those of *phosphate of lime*. They are represented in figure 4, taken from Dr. Bird's original specimen. Although I have elsewhere pointed out this error, most recent writers on the urine still persist in describing these crystals as a variety of the phosphate of ammonia and magnesia.

On the Frequency of their Occurrence.

I find, as already stated, that phosphate of lime in the form of crystals is of much more frequent occurrence in human urine than the triple phosphate, excluding those cases of the presence of the latter phosphate which are due to the decomposition of the urea of the urine subsequent to its emission. I have met with deposits of crystallized phosphate of lime in some hundreds of urines, and in many different cases; it is therefore not a little remarkable, from the frequency of its occurrence and the peculiarities presented by the crystals, that it should have been so long overlooked. The microscope therefore furnishes us in most cases with the ready means of detecting the presence of deposits of phosphate of lime, as of so many other urinary deposits.

Characters of Urine depositing Crystallized Phosphate of Lime.

The urine from which phosphate of lime is deposited is usually pale, but occasionally it is high-coloured; the quantity passed is large, and the calls to void it frequent, more or less uneasiness and smarting being occasioned by its passage, at the neck of the bladder and along the course of the urethra: its specific gravity varies greatly; taking the whole quantity passed in twenty-four hours, it is usually below the average, nevertheless the animal matter and urea are

* The Figures on the preceding page represent selected portions of four of these drawings: all the objects are magnified 100 diameters.

absolutely in excess. It is generally feebly acid, often decidedly so when first voided, the greater part of the phosphate of lime becoming deposited while the urine still retains some degree of acidity; it however speedily becomes alkaline, owing probably to the excess of mucus contained in it. Sometimes the crystals of phosphate of lime are thrown down from the urine before its escape from the bladder; ordinarily, however, the urine is bright and clear when passed, and the crystals are not formed until some time after it has been voided. In collecting this phosphate for analysis, the object being to procure it in as pure a state as possible and as free from phosphate of ammonia and magnesia, oxalate and carbonate of lime, it should be separated from the urine very soon after it has become deposited, and before decomposition has had time to set in.

*On the Pathological Importance of Deposits of Phosphate of
Lime in Human Urine.*

Of the pathological importance of excess of phosphate of lime in the urine not a doubt can be entertained, but certain reasons and facts may be advanced to show that deposits of that phosphate have a deeper pathological significance than those of the phosphate of ammonia and magnesia. The proof of this is the more necessary, since writers on the urine are in the habit of describing, as well as of treating, deposits of the earthy phosphates collectively, and without distinguishing between them: this course was natural enough so long as they were unacquainted with the fact that deposits of phosphate of lime in the state of crystals are of frequent occurrence, or so long as they mistook them for a variety of the ammonio-magnesian phosphate. One reason why we should be disposed to attach greater importance to the excess of the calcareous than the magnesian phosphate, is that most of the phosphoric acid of this last phosphate, and all the magnesia, is derived from *without*, being contained in the various articles consumed as food; while for the phosphate of lime, we have in the system—in the teeth and bones, and also in the nitrogenous tissues—sources containing some pounds weight of this phosphate.

That the osseous system is subject to disintegration is certain, and that the extent and rapidity of this differ remarkably in different cases is equally so. This is shown by the simple fact alone of the

early and rapid decay of the teeth in many persons. For this general reason therefore only, we should, *a priori*, be disposed to attach greater importance to the occurrence of deposits of phosphate of lime than those of phosphate of magnesia.

Other facts tending to confirm this view are, first, that while deposits of phosphate of lime are frequently met with, those of phosphate of magnesia (not the ammonio-magnesian phosphate) are exceedingly rare; and second, that the calcareous is of more difficult solubility than the magnesian phosphate. This last circumstance explains probably why phosphate of lime falls as a deposit from acid urine, while phosphate of magnesia remains in solution.

The particular or special reasons for regarding deposits of phosphate of lime as of more moment than those of the triple phosphate, are derived from direct pathological observation. I have observed that when this deposit occurs, it is very apt to be persistent; and when it has disappeared, to return whenever the health is reduced from any cause. I have also noticed that, when it is persistent, it is usually associated with marked impairment of the health, and this often where organic disease does not exist. The prominent symptoms in one case of calcareous phosphatic deposit which I have had under observation for some years, were,—great disorder of the digestive organs, frequent and distressing headaches, occasional vomiting, debility, emaciation, great irritability of the nervous system, sexual powers weak, pulse slow and feeble, skin cold, urine in excess, of rather low specific gravity, acid when passed, but soon becoming alkaline, micturition frequent, with irritation at neck of bladder and in the course of the urethra: teeth much decayed. It should be stated that there is in this case a very slight tendency to paralysis of the right leg, as shown by an occasional sensation of coldness in the limb, and slight deficiency of power in it at times only. This symptom is, however, by no means a constant or necessary one in such cases.

If these views of the pathology of phosphate of lime be correct, we should expect to find an excess of that phosphate in the urine in great and rapid waste of tissue, during the rapid decay of the teeth, and in cases of *mollities ossium*. That there is an excess of the calcareous phosphate in the urine in these cases, is shown alike by observation and analysis.

It is obvious from this imperfect sketch that much remains to be

effected in regard to the pathology of phosphate of lime; but now that the frequency of its occurrence in human urine as a crystallized deposit is made known, its pathology, apart from that of the triple phosphate, will no doubt be specially considered.

It will be apparent from the following quotation, that the late Dr. Golding Bird regarded deposits of phosphate of lime as of more consequence than those of the triple phosphate :—“The pathological state of the system accompanying the appearance of deposits of phosphate of lime is analogous to that occurring with the triple phosphate; indeed, as has been already observed, they often, and in alkaline urine always, occur simultaneously. So far as my own experience has extended, when the deposit has consisted chiefly of the calcareous salt, the patients have appeared to present more marked evidence of exhaustion, and of the previous existence of some drain on the nervous system, than when the triple salt alone existed, unless its source is strictly local.”

It should be remembered that these remarks of Dr. Bird refer to deposits of phosphate of lime in the *granular state*, and not to the crystalline deposits, with the occurrence of which he was unacquainted. I have already stated that, according to my experience, the granular calcareous phosphatic deposits are much more rare than the crystalline.

It follows from these observations and investigations :—

First. That deposits of *crystallized* phosphate of lime are of frequent occurrence in human urine, much more so, indeed, than those of the amorphous or granular form of that phosphate.

Second. That the crystals present well-marked and highly characteristic forms, whereby the identification of this phosphate by means of the microscope is rendered easy and certain.

Third. That there is good reason to believe that deposits of phosphate of lime are of greater pathological importance than those of the phosphate of ammonia and magnesia.

February 2, 1860.

Sir BENJAMIN C. BRODIE, Bart., President, in the Chair.

In accordance with notice given at the last meeting, the Right Honourable Sir Edward Ryan, Member of Her Majesty's Privy Council,

Fig. 1.

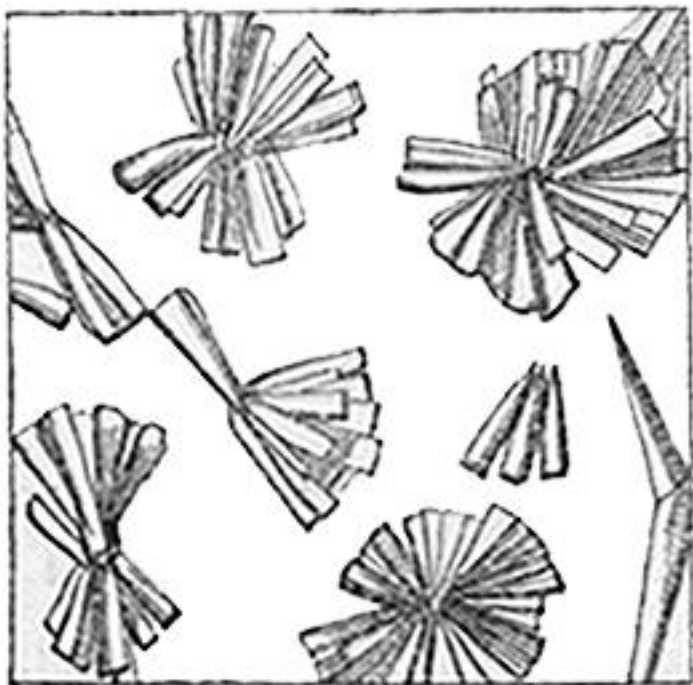


Fig. 2.



Fig. 3.

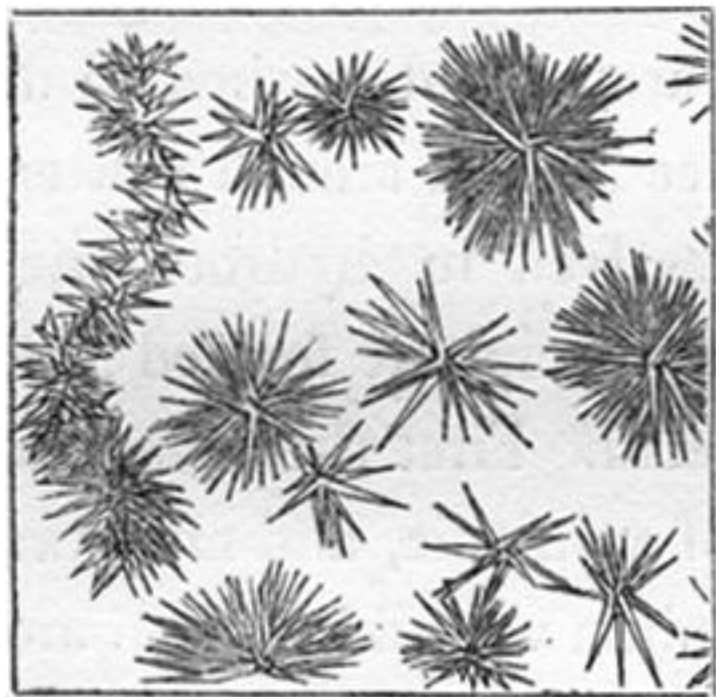


Fig. 4.

