broken to a far greater extent than the outer; this latter surface merely presenting the separation of the edges of the fissure.

Arguing on the frequency of this occurrence in such injuries, he recommends that the most careful examination should be made with the probe, in order that any depression of the internal table may, if possible, be at once ascertained. If present, notwithstanding the absence of symptoms of compression, the trephine is to be applied, and the portions of bone removed, in order to guard against their occurrence hereafter. He thus sums up his convictions on this matter:—"A patient very often survives a mere depression of the skull; he may, and occasionally does, survive a greater depression of the inner than of the outer table; but I do not believe that he ever does survive and remain in tolerable health after a depression with fracture of the inner table, when portions of it have been driven into the dura mater." (*Injuries of the Head affecting the Brain*, p. 94.)

I cannot but think that, had the symptoms led me to have raised the inner table of this patient's skull when I first examined him, he would, in all probability, have had a better chance of permanent recovery.

That a fracture of the internal table, accompanied by depression, occurred at the outset, I have already stated to be my conviction; and I think that any one who examined the specimen, or who now attentively inspects the woodcuts which illustrate these observations, will arrive at the same conclusion. The pressure on the brain exercised by this could not have been at first to any extent beyond a most moderate amount. After a time, as inflammatory action arose in the bones around the injury, my opinion is that a filling in of the diploe by new bone took place, which, as it grew, had the effect of compelling inwards the broken portion of the inner table more and more, until at length that time arrived when its influence on the brain could no longer be endured.

I would remark, also, that the congestion of the vessels of the head, repeatedly present, would appear to have led to that general thickening of the bones of the cranium which was observable in this case, and which brought portions of them to a breadth almost comparable with the thickness of a skull-cap said to be in the possession of Mr. Quekett, nearly an inch in thickness, and originating in a blow received some years before death, from the effects of which recovery had apparently taken place. (*Holden's Human Osteology*, 2nd edit., p. 110.)

We may fairly, then, derive some practical conclusions from the foregoing case. They are briefly stated thus:—

1. The necessity of making a most minute examination of all cases of fissured fracture of the cranium, especially where the injury has been inflicted by cutting instruments falling perpendicularly, although there are neither mechanical nor other evidences present of depression of the inner table of the skull.

2. Supposing the inner table is found to be driven inwards on the dura mater; and, although no symptoms of compressed brain are present, the surgeon, in my judgment, will give his patient a better chance of avoiding future mischief by at once raising, and, if necessary, removing, that which sooner or later must destroy life.

3. There are sometimes cases of epileptic seizures and imbecility, or of continued headache, occurring at a remote period from a former injury to the head, which call for the use of the trephine.

DRINKING FOUNTAINS FOR WESTMINSTER. At a meeting of the vestry of St. James's, Westminster, held on Friday, May 6th, the Rev. J. C. Kemp, in the chair, a communication was received from Samuel Gurney, Esq., in which the advantages of public drinking fountains were stated, and the cooperation of the vestry with the association for promoting their erection was invited. The Hon. F. Byng moved a resolution to the effect, that the vestry propose to the Free Drinking Fountain Association to pay for the supply of water to the fountains erected by the association. Mr. Beale seconded the resolution, and Dr. Lankester, the medical officer of health, urged the necessity of such public drinking fountains being established, and hoped they would be made ornamental as well as useful. Mr. Bidgood supported the resolution, which was unanimously agreed to.

ACADEMY OF SCIENCES IN PARIS. On April 29th, Professor Owen was elected a foreign associate of this learned body, in the room of the late celebrated botanist Robert Brown.

A Course of Lectures ON URINE, URINARY DEPOSITS, AND CALCULI.

DELIVERED AT THE PATHOLOGICAL LABORATORY,
DURING THE SESSION 1857-58.

BY

LIONEL BEALE, M.B., F.R.S.,

PHYSICIAN TO KING'S COLLEGE HOSPITAL; PROFESSOR OF PHYSIOLOGY
AND GENERAL AND MORBID ANATOMY IN KING'S
COLLEGE, LONDON; ETC.

LECTURE II.

Healthy Urine. I. VOLATILE CONSTITUENTS. II. ORGANIC CONSTITUENTS. III. INORGANIC CONSTITUENTS.—VOLATILE CONSTITUENTS: *Water; Carbonic Acid; Peculiar Organic Acids; Ammonia and Ammoniacal Salts.*—ORGANIC CONSTITUENTS: *Urea; Quantity; Characters; Circumstances affecting the Formation of Urea; Origin: Creatine: Creatinine: Guanine: Sarcosine: Inosine: Uric Acid; Quantity; Detection; Mode of Formation: Urates: Hippuric Acid: Extractive Matters: Mucus: Lactic Acid and Lactates.*

GENTLEMEN,—After having discussed the general characters of healthy urine, we may now pass on to consider the characters of the different substances found in this excretion. It is convenient to divide them into three classes, viz.:

- I. VOLATILE CONSTITUENTS;
- II. ORGANIC CONSTITUENTS;
- III. INORGANIC CONSTITUENTS.

The first class includes those substances which are volatilised at the temperature of a steam-bath (212° or less). The most important of these are, *water, carbonic acid, and certain ammoniacal salts.*

The second class contains those organic constituents which are not volatilised at a temperature of 212°, but which are decomposed at a red heat. The most important of these are, *urea, uric or lithic acid, hippuric acid, with urates and hippurates, lactic acid and lactates, mucus from the urinary mucous membrane, creatine, creatinine, and various indeterminate uncrystallisable substances included under the head of extractive matters.* The *colouring matters* before described, and perhaps traces of *leucine, tyrosine, and one or two other less important organic matters*, would be included in this class.

In the third class are found various *saline matters* which remain fixed after the organic matter has been destroyed by a red heat, and the carbon which results removed by prolonged exposure to a dull red heat in contact with the air. These inorganic constituents consist principally of *chlorine, sulphuric acid, and phosphoric acids, and, in some cases, nitric acid, in combination with sodium, potash, soda, lime, magnesia, iron, and sometimes alumina, with traces of silica.*

I.—VOLATILE CONSTITUENTS.

Water. Healthy urine contains from 940 to 960 grains, or even more, in 1,000. The proportion of water is much influenced by various circumstances, especially by the quantity taken in the food, the activity of the skin, and the presence of various substances which influence the chemical changes going on in the tissues, or affect the secreting action of the kidneys. The mode of estimating the proportion of water has been before alluded to. At first this would be supposed to be a very simple matter, but in practice it is found to be one of the most difficult operations in analysis, because many of the organic constituents of urine are prone to undergo changes at a very moderate heat, and even at the temperature of the air, if the concentration is effected too slowly. Practically, it is the best plan to concentrate the urine at a temperature of 100°, and then continue the evaporation *in vacuo* over sulphuric acid until the residue ceases to lose weight.

Carbonic Acid is held in solution in fresh urine: indeed, traces may be detected in all the animal fluids. Its presence may be shown by passing some pure hydrogen gas through urine. After the gas has traversed the urine, it should be conducted into pure lime water, which will become turbid if there be an appreciable quantity of carbonic acid present. This experiment is founded upon the fact that, if one gas be passed

through a solution of another gas, the latter will be displaced by it. By distillation, also, the presence of carbonic acid might be shown; but, in this process, great care must be taken to prevent the production of carbonate of ammonia, which would, of course, cause a precipitation of carbonate of lime in lime water.

Peculiar Organic Acids. Besides carbonic acid, urine contains, according to the observations of Städeler, a peculiar acid to which the name of *damaluric acid* has been given. It has a powerful odour; but little is yet known of the circumstances under which this volatile acid occurs. *Phenylic* or *carbolic acid*, usually known as *creasote*, has also been detected in urine; but these acids, with the *damolic* and *taurylic acids*, as they occur in urine, have as yet been so little studied, that we know nothing of any practical importance connected with them.

Ammonia and Ammoniacal Salts. Another volatile constituent of urine is *ammonia*. The presence of this substance in healthy urine has been doubted by many; but Heintz has shown that the addition of chloride of platinum to fresh urine causes a precipitate which consists of the potassio-chloride of platinum, with a certain quantity of the ammonio-chloride of platinum; the amount of the latter being estimated by determining the quantity of the potassio-chloride in a separate experiment. Ammonia exists as urate and lactate; it is also found in combination with phosphoric acid and soda, and with phosphoric acid and magnesia. Chloride of ammonium is also present.

Ammonia is likewise given off during the decomposition of several of the organic constituents of the urine by heat, as indeed it is from many other nitrogenous organic substances. Thus, if a portion of the solid residue of urine be exposed to a red heat in a small glass tube, much very offensive vapour will be given off, and a carbonaceous residue will remain in the tube. If a piece of reddened litmus or turmeric paper, moistened with distilled water, be applied to the mouth of the tube as soon as it is heated, the blue colour of the former will be restored, and the latter will assume a dark brown tint—reactions which indicate the existence of volatile alkali or ammonia, which arises from the decomposition of the nitrogenous matters.

II.—ORGANIC CONSTITUENTS OF HEALTHY URINE.

Many of the constituents of healthy urine may be obtained in a crystalline form by allowing a few drops to evaporate, at a moderate temperature (about 140°), upon a glass slide, or in a shallow oval glass cell. In this manner, crystals of urea, urate of soda, chloride of sodium crystallised in cubes and octohedra, phosphates, and sulphates, may be readily obtained. The observer should make himself familiar with the appearance of these crystals. (*Illustrations of Urine*, etc.; *Urine*, Plate I.)

The quantity of the organic constituents varies very much, as would be supposed. In healthy urine, about three-fourths of the solid matter consists of organic substances, and there may be found from 12 or 14, to 45 or 50 grains in 1,000 grains of urine. The mode of estimating the amount of solids has been already referred to. The quantity of the organic constituents is easily obtained by burning a weighed portion of the solid matter, and by subtracting the quantity of saline residue which remains. The result is the required quantity of organic constituents.

Urea. The most important of the organic constituents of urine is urea. It is a crystalline substance, very soluble in hot water, and in four or five parts of cold water, soluble in alcohol, but insoluble in pure ether, deliquescent, readily crystallised if pure, but the presence of some organic constituents interferes with its crystallisation. However, good crystals of urea may often be obtained by simply evaporating a specimen of urine upon a glass slide, at a moderate temperature. Urea has a cool saline taste, is perfectly colourless when pure, but has a very strong affinity for the colouring matter of urine. In order to obtain perfectly colourless urea from urine, it is necessary to expose it to the prolonged action of animal charcoal in a diluted state.

Quantity. Urine in health contains from 12 or 15 to 30 or 40 parts of urea per 1,000; and as much as from 400 to 600 grains of solid urea are excreted from the body of a strong healthy man in twenty-four hours. The solid matter of healthy urine contains half its weight of pure urea.

Detection. The presence of urea is very easily detected, if the solution be moderately strong. Here I have some urine which has been slightly concentrated by evaporation, and

afterwards allowed to cool. Upon the addition of a few drops of strong nitric acid, a number of beautiful sparkling crystalline lamellæ make their appearance. These are not very soluble in water, and are easily recognised by their microscopical characters. (*Illustrations of Urine*, Plate III.) In this manner nitrate of urea is prepared.

If, instead of adding nitric acid to the concentrated urine, I were to add a concentrated solution of oxalic acid, I should obtain numerous crystals of oxalate of urea, also a very insoluble salt, and, like the nitrate, crystallising in rhomboidal plates; but the crystals are more perfectly formed, and the inclination of the angles is different. (*Illustrations of Urine*, Plate IV.)

A solution of nitrate of mercury also forms a precipitate with urea; but, in order to apply this test, all the chloride of sodium and phosphates must be removed. Liebig has proposed a most simple and highly efficacious plan for estimating the quantity of urea by ascertaining the amount of a solution of permanganate of mercury, of known strength, which is required to throw down the whole of the urea in a given volume of urine. This process for estimating the quantity of urea, as well as other constituents of the urine, *volumetrically*, will engage our attention in a future lecture.

Characters. Urea crystallises in four-sided prisms, which seem to be composed of a number of acicular crystals. (*Illustrations of Urine*, etc., Pl. II, p. 56.) It melts at 248°, and is decomposed at a higher temperature; cyanate of ammonia and carbonate of ammonia being among the products of the decomposition. It is not decomposed by being boiled in pure water, but mere traces of putrescent animal substances excite rapid decomposition even in the cold. Yeast also exerts the same effect; and mucus and pus produce this decomposition very rapidly, as already remarked under the head of "alkaline urine". The rapid evolution of carbonate of ammonia from urine which has been placed in a dirty vessel, is explained in the same manner.

It is curious that urea causes common salt, which, under ordinary circumstances, crystallises in cubes, to crystallise in octohedra; and chloride of ammonium, which crystallises in octohedra, to crystallise in cubes.

In the laboratory, urea may be formed artificially. By allowing cyanate of ammonia to evaporate to dryness, it becomes converted into urea, in which neither cyanic acid nor ammonia can be detected. Urea is one of the products formed by the action of peroxide of lead on uric acid, and it is also produced by the action of alkalis upon alloxan and creatine. Béchamp stated that he had obtained urea directly from the action of oxidising substances on protein compounds, as permanganate of potash upon albumen. This experiment has been several times tried in my laboratory without success, and several chemists have failed to confirm Béchamp's results; so that we may consider that, up to the present time, no one has succeeded in producing urea directly from the tissues, or from albuminous substances.

Suppose I wish to obtain a specimen of pure urea from urine; an oxalate or nitrate is first prepared, purified by being recrystallised, dissolved in water, and heated for some time in contact with pure animal charcoal. When the solution is colourless, it is decomposed with chalk or carbonate of barytes. The solution of urea is concentrated, so that crystals may form. The pure crystals are very deliquescent; but, with care, they may be dried and preserved for any length of time, if carefully excluded from the air. They form beautiful microscopic objects.

Rich in nitrogen, very soluble in water, readily diffused through large quantities of fluid, and possessing considerable power of permeating animal membrane, urea may be regarded as the principal product resulting from the disintegration of nitrogenous tissues, and as one of the most important excrementitious substances from the animal organism. Not only is urea derived from the products resulting from the disintegration of muscular fibre, but any excess of albuminous materials taken in the food is removed from the body chiefly in the form of urea.

Circumstances affecting the Formation of Urea. The quantity and nature of the food, and all circumstances which affect the nutrition and repair of the tissues, will exert an influence upon the quantity of urea formed in a given time. A liberal diet, rich in albuminous substances, and active exercise, combined with a healthy state of the organs of respiration and circulation, cause the formation of a large quantity of urea; while indolent habits, a diet rich in carbon and poor in nitrogen, insufficient food of any kind, an unhealthy state of the lungs and circulatory organs, and an imperfect supply of

good air, will diminish the proportion formed. I need hardly say that a greater quantity of urea is formed during the day than during sleep; by strong muscular persons, than by weak ones; by men than by women; in winter, when a small quantity of excrementitious substances are removed by the skin, than in summer, when the perspiration is abundant.

In all probability, urea is formed in the organism by the oxidation of uric acid. The latter substance, if the oxidating processes in the body are active, becomes resolved entirely into urea and carbonic acid; but if, on the other hand, these processes are less active than they should be, the uric acid in the urine is increased in quantity; a certain quantity of oxalic acid, and other substances of a lower degree of oxidation than urea, seem to be produced, instead of the whole of the uric acid being resolved into this soluble substance. Wöhler and Frerichs have shown that, if uric acid be taken at night, oxalate of lime is found in the morning urine; and Neubauer found that, when rabbits were made to take a considerable quantity of uric acid with their food, the urea in their urine increased from 1.34 to 4 grammes (from 20.67 to 61.72 grains). Large quantities of fluids cause an increase in the proportion of urea formed in the organism. A dilute state of the solids is favourable to their oxidation; and in certain conditions, where these changes are but imperfectly carried on, and in consequence uric acid accumulates in the blood, or at most is resolved into oxalic acid, the further oxidation is promoted by the administration of increased quantity of fluid, especially of fluids containing alkalis which not only increase the activity of the changes, but effect the solution of the insoluble uric acid and urates. Hence the benefit of alkaline waters, baths, moderate exercise, and plenty of good air, in gout and other conditions in which much more uric acid is formed than can be, under ordinary circumstances, converted into urea.

The quantity of urea excreted is also increased by common salt (Bischoff). It is probable that not only does chloride of sodium, so to say, filter through the different tissues, like other saline substances, and thus drive out other materials which are contained in their interstices; but that it also facilitates the occurrence of chemical change in the body, and directly influences the quantity of urea formed. The importance of chloride of sodium to cell-growth and the development of different textures, and its value in nutrition, are well known.

The beneficial effect of alkalis in different cases is acknowledged by all; and it is probable that this is in part to be explained by the influence they have been proved to possess in promoting chemical change in the body, and especially in favouring the oxidation of albuminous substances. Dr. Parkes has shown conclusively, in an elaborate series of experiments, that liquor potassæ exerts a direct influence of this kind. ("On the Action of Liquor Potassæ on the Urine in Health", *British and Foreign Medico-Chirurgical Review*, vol. xiv, p. 258, January 1853.) The percentage of solids in the urine is increased, the urea is increased, and the proportion of sulphates augmented, owing to the oxidation of the sulphur of albuminous tissues. Franz Simon long ago showed that the sulphates were always increased whenever an increased proportion of urea is formed; and the more recent researches of Dr. Bence Jones lead to the same conclusion. In Dr. Parkes's experiments, the acidity of the urine was hardly affected by the liquor potassæ; and the whole of the potash taken was entirely excreted in the urine, in the form of sulphate, in a very short time; if taken on an empty stomach, in from thirty to ninety minutes. Such facts assist in the most important degree to elucidate some of the most complicated chemical changes going on in the organism, and afford valuable information as to the nature of various morbid changes, as well as suggest the means by which these may be modified or counteracted. For these reasons, I have thought it desirable to dwell upon them rather at length.

On the other hand, both the solids and fluids of the urine are diminished by alcohol; so also is the proportion of carbonic acid exhaled. Tea causes a diminution both in the quantity of urine and faeces, as the beautiful researches of Dr. Böcker have conclusively proved. (*Medico-Chirurgical Review*, vol. xiv.) Coffee exerts a similar effect, which seems to be due, not to the caffeine, but to the empyreumatic oil which it contains, according to Julius Lehmann. These substances, tea, coffee, and alcohol, in moderate quantity, affect the disintegration of tissue, and directly diminish the quantity of the excrementitious substances formed in the process. Supposing the food to be insufficient, the loss of weight which must necessarily take place in the body would be lessened; and they may, therefore, be regarded as advantageous, not only in economising the food, but

in limiting to some extent the waste of the albuminous tissues.

In disease, the proportion of urea excreted varies very greatly; but upon this head I shall have more to say in a future lecture.

Origin. Urea is not formed in the kidneys, but exists in the blood, and is merely selected or separated from this fluid by the cells of the uriniferous tubes. It is with difficulty detected in healthy blood, because it is prevented from accumulating in that fluid in sufficient quantity by the selective power of the renal epithelium.* If, however, the secreting action of the kidneys be impaired by disease, or if the blood be prevented from flowing through them, the urea will accumulate in the blood to a considerable extent, interfering with the function of other organs, especially the brain; and may in many cases be very readily detected by chemical tests.

Under these circumstances, an incomplete removal of the urea will take place through other channels. It has been detected in the fluids of the intestinal canal, in vomited matters, in the saliva, tears, milk, bile, and sweat, in serous fluids in different localities, in the liquor amnii, and in the fluids of the eye.

Urea cannot always be detected in the muscles, but can be readily produced from several substances found in them; and it is therefore probable that, in the organism, urea forms the last of a series of compounds which results from the disintegration of the tissues. Removed from the body, very slight causes are capable of effecting its decomposition, and resolving it into ammonia and carbonic acid—substances of the highest importance to the growth of plants.

[To be continued.]

Gulstonian Lectures

ON

FEVER AND INFLAMMATION.

DELIVERED BEFORE THE

ROYAL COLLEGE OF PHYSICIANS, LONDON,
1859.

By WILLIAM ADDISON, M.D., F.R.S., Fellow of the College.

LECTURE II.

IX.—FEVER.

WHEN a person is inoculated with the virus of small-pox, a poison is introduced into the body—nay, into the blood. That it distempers the blood, is concluded from the generality of the symptoms.

These are, rigors and shivers over the whole body; to which succeed a fever, hot skin, quick pulse, and general illness, accompanied with severe pain in the back and head, inclination to vomit, pain on light pressure at the pit of the stomach, stupor, and drowsiness.

Counting from the first invasion of the fever, the pustules of small-pox arise on the fourth day, rarely sooner. At first very small, they grow greater every day, and rise more and more to a head filled with pus. About the eighth day, the spaces between the pustules look red, and the hands and face swell. On the eleventh day, the swellings are evidently going down, and the pustules have reached their full magnitude. At this time, the fever has greatly diminished or wholly vanished.

Matter taken from any of the pustules will reproduce the fever with certainty in a person who has never had it. The virus, therefore, has been multiplied a myriad-fold—regenerated in the body of the patient. And the question proposed is: To what element of the tissues or of the blood is the reproduction of the virus to be attributed? The pustules do not make their appearance until some days after the fever; excluding them, therefore, from any share in *generating* the virus, the plasma and the corpuscles of the blood remain for examination.

Liebig, it is well known, ascribes the phenomena which succeed the introduction of the small-pox virus into the blood to

* Dr. Thudichum attributes the failures of observers to detect urea in the blood, to their precipitating the albumen by heat. If the blood be treated with strong alcohol, the urea is dissolved, and the albumen rendered insoluble at the same moment. The former can be detected in the alcoholic solution.