GENERAL VIEWS
OF
THE COMPOSITION
OF
ANIMAL FLUIDS.

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COMMUNICATED BY

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HAVING related to my friend Dr. Marcet, some observations that I have made on the subject of Animal Chemistry; and being invited by him to communicate them to the Medical and Chirurgical Society, I shall, in compliance with his wish, venture to submit to the Society, some of the principal results that I have obtained at different periods, prior to my visit to this country, respecting the Fluids of Animals. Most of these observations have been published in a more unconnected state in different works in the Swedish language *; but

* In my "Föreläsningar i Djurkemien, 2 Vol. Stockh. 1808. And also in Afhandlingar i Fysik, Kemi och Mineralogie, 3 Vol. Stockh. 1810."

as they have not been translated into any other language, and as they have appeared to those who have seen them, to contain some new views, I am induced to offer them to the Society, in the hope that they will be received with indulgence.

I. *Of the blood.*

In most of the analytical researches on blood, that of the bullock has been made the subject of experiment. I shall therefore begin with the analysis of the blood of that animal, and afterwards notice the essential points in which I have found it to differ from the human.

Of Bullock's blood.

Blood may be regarded as a liquid holding a colouring matter suspended in it, but not dissolved. The first step in the process of accurate analysis should therefore be to separate the suspended matter by filtration. But this method succeeds only to a certain degree, and requires a time so considerable, that the blood undergoes spontaneous changes of composition before the separation can be completed: for notwithstanding all possible care, the colouring matter will either pass through with the fluid portion, or by adhering in masses, prevent all further percolation. Another mode is that of allowing it to subside by rest: but this also goes on with extreme slowness: the clear supernatant liquor loses its red colour but very gradually; and the colourless portion is not capable of being collected alone.

The usual way of obtaining them separate is to take advantage of the coagulation of the blood, during which the fibrin enveloping the colouring substance, presses out the serum. This method is indeed but very imperfect, as a large portion of the serum still remains attached to the red globules in the coagulum ; but it is the only one that we can employ.

I shall first consider the crassamentum, and its two constituent parts, fibrin and colouring matter.

Of the Chemical Properties of Fibrin.

1. Fibrin is insoluble in cold water. In boiling water it curls up, and after the ebullition has continued some hours, the water acquires a milky hue, but no gaseous product appears. By this operation fibrin undergoes a species of decomposition ; the water in which it is boiled affords, by the addition of tannin, a precipitate of white and distinct flocculi, which do not cohere together by the heat, as those produced by gelatin. The evaporated liquid does not gelatinize to whatever degree it may be concentrated, and leaves a white, dry, hard and friable residue, which is soluble in cold water, and has an agreeable taste similar to fresh broth, and totally unlike the salt and acrid flavour of the extract from muscles. Fibrin, by long boiling in water, loses its property of softening and dissolving in acetic acid.

2. In *alcohol* of specific gravity 0.81 fibrin undergoes a species of decomposition, and forms an adipocirous matter, soluble in alcohol, and precipitated by the addition of water; having often a very strong and unpleasant odour. The alcoholic solution leaves on evaporation a fat residue, which did not pre-exist in the fibrin, and which, as we shall find, is likewise formed by the action of alcohol in the colouring matter and on the albumen. Fibrin heated in alcohol, retains its property of softening and dissolving in acetic acid.

3. By the action of *ether*, fibrin is converted into an adipocirous mass similar to the preceding, but in much greater abundance, and having a much stronger and more disagreeable odour. We are on this account precluded from employing generally either alcohol or ether in analytical experiments on animal substances.

4. In concentrated *acetic acid*, fibrin becomes immediately soft, transparent, and with the assistance of heat is converted into a tremulous jelly. By adding water and warming it, this jelly is completely dissolved, with the evolution of a small quantity of azotic gas. The solution is colourless, of a mawkish and slightly acid taste. During its evaporation a transparent membrane appears on the surface, and after a certain degree of approximation, the gelatinous substance is again re-produced; but this gelatine has no resemblance to that formed by paste.

When completely desiccated it is a transparent mass which reddens turnsol paper, but which without a fresh addition of acetic acid is insoluble both in cold and boiling water. The solution of fibrin in acetic acid added to prussiate of potass or of ammonia, gives a white precipitate, without any separation of prussic acid. This solution will also produce a precipitate by alkalis, but it is redissolved by a small excess of the latter. Sulphuric, nitric, and muriatic acids afford likewise a precipitate with this solution: and the precipitate, is composed, as we shall presently see, of fibrin and the acid employed. If the precipitate be laid on a filter and washed, a certain quantity of this acid is carried off by the water, and the remaining substance is soluble in pure water. The solution contains a neutral combination of fibrine with the mineral acid employed which is mucous, somewhat opeline, and of an acidulous taste. An addition of acid will again precipitate it, and it thus often happens that an animal substance that has been treated with a mineral acid and washed on the filter, gives at length a clear liquor which becomes turbid on falling into the acid liquor that had first gone through. This phenomenon always indicates the presence of the abovementioned combination of a mineral acid with fibrin, or with albumen, which appears to possess the same chemical properties as fibrin.*

* It may be observed that the precipitate produced by nitric acid, assumes a yellow colour, but has in other respects the same properties as the two others.

4. In weak *muriatic acid*, fibrin shrinks and gives out a small quantity of azotic gas ; but scarcely any portion is dissolved even by boiling ; neither does the acid liquor afford any precipitate with ammonia, or with prussiate of potass. Evaporated to dryness a brownish residue is obtained, from which potash disengages a little ammonia. Concentrated *muriatic acid* decomposes fibrin by coction, and produces a red or violet-coloured solution.

The fibrin that has been digested with weak *muriatic acid* is hard and shrivelled. By washing repeatedly with water, it is at length converted into a gelatinous mass, which is perfectly soluble in tepid water. The solution powerfully reddens litmus paper, and yields a precipitate with acids as well as with alkalies. Fibrin has therefore the property of combining with *muriatic acid* in two proportions. The one gives a neutral combination soluble in water ; the other, a combination with excess of acid which is insoluble, but which is reduced to the state of the soluble compound by the action of pure water.

5. Concentrated *sulphuric acid* decomposes and carbonises fibrin. The same acid diluted with six times its weight of water, and digested with fibrin, acquires a red colour, but dissolves scarcely any thing. The fibrin that is not dissolved is a combination of it with an excess of *sulphuric acid*. By depriving it of this excess of acid, by means of pure water, a neutral combination is obtained which is

soluble in water, and possesses the same characters as the neutral muriate of fibrin.

6. *Nitric acid* of the specific gravity 1.25 digested with fibrin, renders it yellow, and diminishes its cohesion. The fluid becomes yellow, and the surface of the fibrin is covered with a small quantity of fat formed by the action of the acid. During this operation elastic matter is disengaged, which is azotic gas alone, and in which I could not discover the smallest portion of nitrous gas. When the digestion has been continued twenty-four hours, the fibrin is converted into a pulverulent mass, of a pale citron colour, which is deposited at the bottom of the liquor. The latter being decanted off, and the undissolved matter placed on a filter and washed with a large quantity of water, the colour changes in proportion as the acid which was in excess is carried off, and the mass acquires a deep orange colour. Even when the affusion is continued till the water gives no sign of acidity, the orange mass has not yet lost the property of reddening litmus.

This yellow substance was discovered by Messrs. Fourcroy and Vauquelin, who obtained it in treating muscular flesh with nitric acid. They have described it as a new acid formed by the action of nitric acid on the muscular fibre, and to which from its colour they have given the name of yellow acid. (*Acide jaune*). This substance is dissolved in caustic alkali, to which it imparts an orange colour,

and it is partly soluble in acetate of potass and of soda. The French chemists found that if treated with a fresh quantity of nitric acid, it acquires the property of burning with the same phenomena as a combustible body mixed with nitre. This fact they considered as remarkable, since they could not detect any nitric acid in the yellow acid. But the latter, as will be presently shewn, is nothing more than a combination of fibrin with nitric acid, (or in other cases, perhaps, with nitrous acid,) and also with another acid formed by the decomposition of a portion of the fibrin, a species of combination very analogous to the one already described. If the yellow substance be boiled with alcohol, a yellow adipocirous matter is taken up; but it is deposited when the liquor cools. This sebaceous matter has a great resemblance to that obtained by the action of alcohol on pure fibrin. If the yellow substance, after being thus deprived of its adipocirous portion, be digested with water and carbonate of lime, it slowly decomposes the carbonate, disengages its acid in the form of gas, and produces a yellow solution. Having separated this fluid from the undissolved portion of the yellow substance, I concentrated it to the consistence of a syrup: and then poured in alcohol, which precipitated one part, retaining the other in solution. The precipitate had all the characters of malate of lime. Dissolved in water, and decomposed by a sufficient quantity of sulphuric acid, it yielded sulphate of lime; and the acid liquor being filtered and evapo-

rated, gave a brownish and highly acid syrup, possessing all the properties of malic acid. The portion dissolved in the alcohol was evidently a mixture of nitrate and nitrite of lime. The mixture consisting of undecomposed carbonate of lime, and the insoluble part of the yellow substance, being decomposed by diluted muriatic acid, left a yellow mass perfectly similar to the one which I had before decomposed, and possessing, like that substance, the property of reddening litmus paper. It appeared therefore that I had merely exchanged the nitric and malic, for the muriatic acid.

We thus find that fibrin enters into combination as readily with nitric acid, as with the other before-mentioned acids, and that it is capable of forming two combinations, the one containing an excess of acid and having a pale yellow colour, the other neutral and of an orange hue. By digesting fibrin with nitric acid, it undergoes a species of decomposition by which malic acid is formed. This acid, in conjunction with the nitric acid, combines with the undecomposed fibrin. The fibrin thus united with the two acids is certainly in some degree altered, for its neutral combination with nitric acid is insoluble in water, and retains its insolubility and its yellow colour even when the nitric acid has been displaced by muriatic. On the other hand, we have seen that the precipitate thrown down by nitric acid from a solution of fibrin in acetic acid, acquires a yellow tinge, but that water in depriving

it of the excess of acid, renders it gelatinous and again soluble. It follows that the fibrin, which, in the yellow body, performs the office of a saline base to the nitric acid, must be modified in a different manner from what it is in fibrin combined with the acids in the soluble combinations.

The nitric acid, in which the yellow substance has been formed, has a bright yellow colour: it holds in solution a portion of the yellow substance with a quantity of malic acid. Mixed with alkali in excess, it assumes a very dark yellowish brown colour.

7. In *caustic alkali*, fibrin increases in bulk, becomes transparent and gelatinous, and at length is completely dissolved. The solution is yellow with a shade of green. Acids occasion in it a precipitate which gradually becomes confluent. The solution of fibrin in caustic alkali is precipitated by alcohol, which by means of the excess of alkali dissolves a portion of the neutral combination of fibrin with alkali. If the aqueous alkaline solution be evaporated, a coagulum is formed towards the end of the process, probably in proportion as the alkali becomes carbonated. The action of alkali upon fibrin produces some alteration in its properties, for the precipitate thrown down by acetic acid does not dissolve by an additional quantity of acid. But whatever be the nature of this change induced on fibrin by the alkalies, the former is by no means

converted, as M. Fourcroy has alleged, into a fatty substance with which the alkali produces a saponaceous compound, nor has it even the least analogy to any species of soap. As far as I can perceive, this effect of alkalies is confined to the epidermoid textures, and parts which by long and continued boiling are converted into a similar substance.

Of the Colouring Matter and its Chemical Properties.

In order to separate, as much as possible, the colouring matter from the albumen and the salts of serum, I cut the crassamentum into very thin slices which I placed upon blotting paper, till it had taken up all that it could absorb: after which they were dried. A portion of the crassamentum treated in that manner, was triturated with water as long as it appeared capable of acting as a solvent. This water acquired from the matter it had dissolved, a brown colour of so deep a shade that it did not exhibit the least transparency when contained in a glass tube of a quarter of an inch in diameter. The fluid had a faint odour of blood, and a mawkish, saline and highly nauseous taste.

I coagulated the solution by means of heat in a pneumatic apparatus. The mass frothed considerably, but no elastic fluid was disengaged. While yet hot, it was placed on a filter: the liquor had a red colour which it lost by cooling, and at the same time deposited a small quantity of the colouring matter. I shall revert to this liquor in the sequel.

The dark brown coagulated matter, after being carefully washed, and subjected to a powerful press, was dried at a temperature of 70° (centigrade thermometer.) It was but little contracted by the exsiccation, but had become black, hard, difficultly pulverisable, and shewed a vitreous fracture. Before the desiccation is complete, it is of a dark brown colour, has little cohesion, and forms a granulated mass: circumstances by which it may be distinguished from both fibrin and albumen.

1. The colouring matter is acted upon by *boiling water* in nearly the same way as fibrin, becoming somewhat contracted by coction; and the solution contains soda, and an animal matter perfectly analogous to that which is obtained from fibrin, but rather less in quantity: for it would appear that a portion of this substance begins to be formed from the commencement of the process of coagulation. It retains its black colour, but loses the property of softening, and dissolving in acetic acid.

2. *Alcohol* and *ether* convert the colouring matter in part, into a fatty adipocirous mass, having a very disagreeable odour.

3. In *acetic acid*, the colouring matter immediately becomes soft, forming a black and tremulous jelly, which dissolves in tepid water with the disengagement of a small quantity of azotic gas. The solution is reddish brown and only semi-transparent.

A small part of the colouring matter remains undissolved, and forms with the acid a compound of very sparing solubility.

A solution of the colouring matter mixed with acetic acid does not coagulate; but when made to boil turns black and deposits a very small quantity of its insoluble compound, without however coagulating.

The solution of the colouring matter in acetic acid is precipitated both by alkalies and by alkaline prussiates. Ammonia produces a dark brown precipitate, which when well washed and weighed, is found to be the colouring matter unaltered, and again soluble in acetic acid. The solution after precipitation by ammonia is yellow, and deposits by evaporation a quantity of white matter, which is readily distinguished to be albumen, of which it is impossible entirely to deprive the crassamentum.

Prussiate of ammonia precipitates from the acetic solution a mass of a blackish brown colour, resembling the precipitate by pure ammonia. Both these precipitates, employed as pigments, give the same shade of dirty brown. The prussic acid, therefore, appears to exert no action on the colouring matter of the blood; which should take place if the latter owed its colour to a ferruginous salt. The solution of colouring matter in acetic acid is precipitated by the mineral acids, and the precipitates have pre-

cisely the same characters, excepting the colour, which is brown, as those procured by the same methods from fibrin.

4. Concentrated *muriatic acid* does not dissolve the colouring matter, even when aided by digestion: a small quantity of azotic gas is disengaged, and the acid assumes a yellow tint: alkalies, however, produce in it hardly any precipitate. The undissolved portion is a compound with excess of acid which becomes soluble in proportion as the superabundant acid is carried off. The neutral solution of colouring matter is brown, and has the same properties as that formed by acetic acid. The colouring matter boiled for a long time with muriatic acid, suffers a commencement of decomposition: some iron is taken up by the acid, and the undissolved portion is no longer soluble even by repeated washing, although in this state it retains a portion of acid, of which the water cannot deprive it.

5. *Nitric acid* produces the same effects on the colouring matter as on fibrin; the only distinction being in the colour, which in the former is invariably black.

6. *Caustic Ammonia* dissolves the colouring matter assuming a very deep brown colour. A precipitate is thrown down by acids, but not by the alkaline prussiates. The precipitate formed by

acetic acid is again soluble, but only by an excess of acid.

7. In solution of *caustic fixed alkali* the colouring matter is softened, forming a brownish jelly, which is dissolved by a sufficient quantity of water. During the evaporation it coagulates in proportion as the alkali absorbs carbonic acid. The alkaline solution is precipitated by alcohol, which, however, acquires a red tinge by dissolving a small quantity of the compound formed of the colouring matter with the excess of alkali. The alkaline solution of colouring matter seen by day-light has a green colour, but appears red by candle-light. It was upon this appearance of green that Fourcroy conceived the idea that bile might be formed by boiling blood with a small quantity of water; but this green fluid, as we shall afterwards see, agrees with bile in no property excepting colour.

8. If a solution of the colouring matter in water be exposed to a heat of 50° (centigrade thermometer) in a saucer, it blackens and dries completely without coagulating. In this state it is again entirely soluble in cold water.

These experiments prove that the colouring matter has the same chemical properties, and consequently the same chemical composition as fibrin, but that these two bodies are distinguishable from

one another principally by a difference in colour; by the fibrin coagulating spontaneously in all temperatures, while the colouring matter may be dried, without losing its solubility in water, and becomes insoluble only at a certain temperature: and lastly by the peculiar character of the latter when coagulated, such as its not being diminished in volume during the exsiccation, as happens with fibrin.

Inquiry into the influence of the iron contained in the colouring matter, in producing its colour.

The greatest chemical difference that is found between fibrin, albumen, and colouring matter, consists in a quantity of oxide of iron being contained in the ashes of the colouring matter, while none, or at least an infinitely small portion is afforded by the others. Parmentier and Deyeux, to whom we are indebted for an elaborate memoir on the blood, have conjectured that the iron, contained in the blood, was dissolved in a way analogous to the alkaline tincture of Stahl, an opinion which has since been controverted by Fourcroy and Vauquelin, who, on their side, have endeavoured to prove that the colouring matter of the blood was a solution of red subphosphate of iron in albumen. We shall find that neither of these theories can be true, and that the mode in which the iron is combined with the colouring matter will probably long remain unknown.

The colouring matter dried, and exposed to fire in an open crucible, melts and swells up, and at last burns with flame. It leaves behind a porous coal, which cannot be incinerated without the greatest difficulty. For this purpose it must be reduced to a very fine powder, and exposed to the fire in very thin layers. While the charcoal is consuming, it continually exhales a smell of carbonate of ammonia, which proves that the constituents of ammonia are not disengaged from the charcoal by heat alone, but that the influence of oxygen is also required in order to effect the separation. The ashes remaining after the destruction of the carbon is yellow and pulverulent.

The disengagement of ammonia from a mass of burning charcoal which has already been exposed for a long time to fire, is undoubtedly a very remarkable phenomenon; but another and a no less singular fact is presented by the same substance. If the charcoal which has already been long burning, and whose surface is covered with yellow ashes, be pulverised and boiled in nitro-muriatic acid, the acid dissolves the ashes already formed, but does not deprive the remainder of the charcoal of the property of affording a fresh quantity of ashes on re-exposure to the fire. These observations seem to prove that the carbonaceous matter of the colouring substance which remains after the flame has ceased to appear, and after the whole mass has

been subjected to a strong red heat, cannot be, as was before supposed, a mechanical mixture of charcoal with the phosphates and carbonates of the earths and of iron. We must therefore consider it as a chemical compound of carbon, phosphorus, sulphur, with calcium, ammonium, and iron; and it appears that it is in a mode analogous to this combination that the iron as well as the calcium, phosphorus, &c. are united with the charcoal, and other constituents of the colouring matter; for it is very evident that the mode in which combustible bodies combine with one another, and with a small portion of oxygen in organic substances, is totally different from that which prevails among the inorganic productions of nature.

To return to the ashes of the colouring matter; water extracts from it a very small quantity of soda mixed with muriate of soda. I have great reason to suspect that these two constituents are merely accidental, and that they appear in consequence of the impossibility of freeing the crassamentum entirely from serum. If the alkaline liquor which is obtained from the ashes, be saturated by acetic acid, evaporated to dryness, and again dissolved, a precipitate will appear on the addition of lime-water, which is phosphate of lime, but in so minute a quantity as not to be appreciable.

I incinerated 20 grammes (400 grains) of colouring matter, till the charcoal was completely destroy-

ed, and obtained 0.25 grammes (5 grains) of ashes having a yellowish red colour. By an accurate analysis, I found it composed of

Oxide of iron	- - -	50.0
Subphosphate of iron	- -	7.5
Phosphate of lime with a small quantity of magnesia	} -	6.0
Pure lime	- - -	20.0
Carbonic acid, and loss	-	16.5
		<hr/> 100.0 <hr/>

But this phosphate of iron was not, in all probability, contained in the colouring matter, not even in the ashes: it has evidently been a product of the analytic process. It is produced in like manner when oxide of iron and phosphate of lime are dissolved together in an acid, and afterwards precipitated with caustic ammonia. Part of the lime remains in solution, and the iron seizes upon its phosphoric acid.

But as one mode of argument will hardly suffice to overturn a theory maintained by chemists of such eminence as Fourcroy and Vauquelin, and for the support of which they have brought forward many positive facts, I have made a number of experiments with a view of throwing light on this subject, and have not met with a single one, which did not appear in contradiction to the opinion of

these celebrated analysts. Some of these experiments I shall now relate.

(A.) The prussiates, as we have already seen, produce no effect on the colouring matter of the blood; and yet they detect, after 24 hours, the least quantity of any ferrugineous salt added to it, having the red oxide of iron for its basis.

(B.) A watery solution of colouring matter, mixed with gallic acid, acquires a beautiful red colour, but the acid produces no precipitate. by adding to the solution of colouring matter one or two drops of a dilute solution of tannin, the liquor becomes of a beautiful red, without any precipitate appearing. But if on the contrary, the solution of tannin be concentrated, it precipitates the colouring matter, and gives it a pale red colour. None of these effects seem to prove the presence of a salt with the base of oxide of iron.

(C.) The aqueous solution of colouring matter, mixed with solution of barytes, is not precipitated: at the end of 24 hours a small quantity of phosphate of barytes is found at the bottom of the vessel, and the liquor has assumed a green colour by the action of the alkaline base. Lime water produces no change.

(D.) A solution of sulphuret of potash produces no change in the solution of colouring matter, ex-

cept that the red colour is slowly converted into green by the action of the alkali. A drop of acetic acid precipitates the sulphur of a white colour.

(E.) It is well known that none of the mineral acids deprive the colouring matter of its colour, which ought to be the case if that colour had been owing to the presence of the subphosphate of iron. The phosphoric acid mixed with the colouring matter blackens without precipitating it: whereas, if the opinion of the French chemists were correct, it ought to produce a neutral and colourless phosphate.

(F.) A drop of a solution of acetate of lead exalts the colour of the colouring matter, and a larger quantity throws down a fine red precipitate.

(G.) The nitrates of silver, of lead, and of mercury blacken the colouring matter, and when added in larger quantity precipitate it.

These experiments prove that the iron in the colouring matter is not contained in it in such a way as to admit of being detected by the best re-agents we possess, until the composition of the colouring matter is totally destroyed.

But how can these facts be reconciled with the following, mentioned by Fourcroy in his *Système des Connoissances Chymiques*? “Vauquelin and I,” says

he, " have found that the subphosphate of oxide of iron is easily dissolved in albumen by a slight agitation and without the aid of heat, and that this solution possesses a bright red colour, similar to that of the blood. This colour becomes still more vivid by adding a little caustic alkali, which facilitates still more the solution of the subphosphate in albumen."

It was not till after having made and carefully repeated many experiments, that I could venture to pronounce this opinion to be void of foundation. I shall not seek to form any conjecture with regard to the circumstances which may have deceived these distinguished chemists, but shall merely relate my own experiments on the subject.

The subphosphate in question, newly prepared and still moist, easily mixes with serum, giving it the colour of rust; but it subsides in process of time, and may be entirely separated from it by means of a filter. The neutral phosphate of oxide of iron, mixed with serum also, does not dissolve, and the addition of caustic alkali instantly produces the subphosphate; but this last remains undissolved, and communicates to the liquor a colour of rust, which is quite dissimilar to that of the colouring matter of blood. The serum deprived of subphosphate by filtration retains a pale yellowish colour, which is owing to a small quantity of oxide of iron held in solution.

If serum is mixed with the subphosphate in question, and phosphoric acid is added, so as to dissolve the subphosphate, a clear rust-coloured liquor is formed, from which a small addition of caustic alkali precipitates a little albumen, which is again dissolved by a slight excess of the alkali ; and then the solution loses its red colour, and the subphosphate falls down, and may be collected on the filter.

In all these experiments the albumen dissolves the oxide of iron, even in greater quantity than exists in the colouring matter of the blood ; but this solution is yellowish, and has but little body of colour ; and the oxide of iron is shewn by the usual reagents. The albumen of serum will also dissolve many other metallic oxides, for instance, that of copper, as Vauquelin has long since proved ; and it is doubtless the albumen which is the menstruum of the oxide of mercury, found dissolved in the blood during a course of this metal for the cure of syphilis. The oxidulum (or black oxide) dissolves easily, and still more copiously, in serum, forming a perfectly limpid sea-green liquor. The solution is readily obtained by adding to serum some salt of iron, which has the black oxide for its base, and neutralizing its acid by an alkali. When this green solution is exposed to the air, it absorbs oxygen, deposits red oxide of iron, and becomes yellow. The compounds of oxide of iron and albumen are decomposed by the mineral acids, which

precipitate the albumen colourless, and retain the iron in solution. The prussiates alone do not disturb the solution of iron in albumen, because the metallic oxide is not here dissolved by any acid; but if, after mixing them, a little muriatic acid is added, an exquisitely beautiful azure blue precipitate appears, consisting of albumen and Prussian blue. If the acid phosphate of iron is dissolved in acetic acid, and afterwards serum be added, followed by a little caustic alkali, the albumen and subphosphate are precipitated together, of a rust-colour, which is not changed by drying, but has no resemblance to the colouring matter of blood. In a word, I have not been able to find any method of combining albumen with subphosphate of iron, or with any other salt of this metal, so as to produce a compound identical with the colouring matter of the blood.

But from the result of all these experiments, what appears to be the difference between venous and arterial blood? This question I am unable to answer; nor can I explain the difference between these substances before and after coagulation.

I have already mentioned that the liquid out of which the colouring matter has been coagulated by heat, has at first a tint of red, which it loses by cooling; at which time it further deposits a small quantity of colouring matter. This liquid, whilst evaporating, becomes green, owing to the action

of the uncombined alkali on the small portion of colouring matter that it still retains. This liquid holds also in solution all the salts, and the soluble animal substances belonging to that portion of the serum which still adheres to the coagulum, and cannot be entirely separated from it. The coagulum, I have found by one analysis, to consist (exclusive of the saline and uncoagulable ingredients) of 64 parts of colouring matter, and 36 parts of an insoluble mixture of fibrin and albumen.

Of the Serum, Albumen, and Salts of the Blood.

When serum is heated in a glass vessel, over a water-bath, it solidifies and forms a pearl-coloured jelly, transparent at the edges. If it is stirred the coagulation is more uniform. It has been said to blacken any silver instrument employed to stir it; but this only happens when the serum has begun to putrefy, or when the bottom of the coagulum has been burnt. As this blackening of silver is owing to sulphur, this substance has also been reckoned among the constituent parts of blood. But it would be equally proper to consider carbon and hydrogen as constituent parts, since these enter into the composition of albumen, in the same way as sulphur does.

Muriatic acid coagulates serum. When heated, a small quantity of azotic gas is evolved. This coagulum has exactly the same properties as the compound of fibrin and muriatic acid.

The sulphuric and nitric acids also produce with the albumen of serum precisely the same compounds as with fibrin.

Phosphoric acid does not coagulate serum.

The acetic acid does not coagulate serum, and when this acid is in sufficient quantity, it prevents the coagulation on heating.

In short, the albumen of serum produces exactly the same compounds with acids and alkalies as the fibrin does, and therefore to avoid repetition, I shall refer the reader back to my observations on this latter substance. The action of alcohol also is perfectly similar in both cases.

There appears therefore to be very little difference between fibrin and albumen; and the latter seems to be intermediate between fibrin and the colouring matter. The only character of distinction between fibrin and albumen is, that albumen does not coagulate spontaneously, but requires a higher temperature for that purpose. Coagulated albumen does indeed dissolve more slowly than fibrin or colouring matter in acetic acid and in ammonia, but probably this is owing to the influence of the heat employed for its coagulation.

Exp. 1. 1000 parts of serum evaporated to perfect dryness, (that is to say, so as easily to be re-

duced to powder,) left ninety-five parts of a yellowish, semi-transparent mass, resembling amber, that split to pieces in drying, which, in curling up, carried with them thick scales of the porcelain glazing of the evaporating vessel.

2. I digested ten grammes of the dried powder in cold water. The albuminous portion softened, and became gelatinous. I separated by the filter the liquid from the insoluble part, and washed the latter repeatedly with boiling water. The undissolved albumen dried in the filter, weighed 6.47 grammes, and did not give up its earthy phosphate, by subsequent digestion in muriatic acid, as this acid remained clear on saturation with an alkali.

3. The solution which had passed the filter, was evaporated to dryness, during which thick membranes formed at the surface, and the solution gelatinized before it was perfectly dry. I digested this residue in alcohol, whilst it was still gelatinous; the spirit assumed a yellow colour, and on evaporation left an alkaline yellowish deliquescent mass, weighing 0.92 grammes. This consisted of soda, holding albumen in solution, of muriate of soda, and muriate of potash, of lactate of soda*, and of an

* In mentioning the *lactate of soda* in this place, I wish to make some observations on the lactic acid, as one of the constituent parts of all animal fluids. It is well known that this acid was discovered by my illustrious countryman, Scheele. Latterly,
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animal matter which always accompanies the lactate.

The portion not dissolved by alcohol and digested with water, left a fresh residue of albumen, weighing 1.95 grammes, and possessing the same characters as that of exp. 2. The watery solution

the French chemists have examined this acid; and Fourcroy, Vauquelin, Thenard, and Bouillon La Grange, have sought to prove that Scheele was mistaken in the supposed peculiar nature of this acid, and that it is only a combination of acetous acid, with some animal matter.

These chemists, however, have made no attempts to obtain this animal matter separate from the acid, and have never succeeded in producing the lactic acid by means of the acetic; but this is the proof which they give of Scheele being in an error. Lactic acid is combined with an alkali, the resulting lactate is distilled with concentrated sulphuric acid, and in the receiver is obtained a mixture of sulphureous, muriatic, and empyreumatic acetic acid, the latter of which is purified, and hence it is, that we are informed that the pretended lactic acid is only the acetous united with some animal matter. But it appears to me, that the French chemists have only cut the Gordian knot; for one of the properties of the lactic acid, is to be incapable of volatilization, and it is a property of the sulphuric acid to change many organic substances with which it is distilled, into the empyreumatic acetous and sulphureous acids. By a parity of reasoning, almost every one of the freed vegetable acids might be proved to be only acetic acid, combined with some matter which deprives it of its volatility, without destroying its other acid properties; and in fact it is thus, that Bouillon La Grange has inferred that the malic and gallic acids are only varieties of the acetic. In an analysis of muscular flesh, which I made in the year 1806, I found that the humours of the muscles contained a free acid, which, by many experiments, I discovered to have all the properties which

characters as that of exp. 2. The watery solution could not be made to gelatinize, and did not hold the smallest quantity of gelatine. Besides the alkali, it contained an animal matter easily precipi-

Scheele attributes to the lactic acid. I collected a quantity large enough for examination, and I succeeded by different methods, in obtaining it in greater purity than Scheele had procured his. I examined a great number of its saline combinations, with alkalis, earths, and metallic oxyds, the particulars of which are given at length in the second volume of my *Treatise on Animal Chemistry*, Stockholm, 1808. p. 430. & seq. If therefore it is allowed, that two acids that produce saline compounds different from each other, cannot be identical in their nature, the distinction between the lactic and the acetic acids cannot be controverted. It is since that time that I have discovered the lactic acid, free or combined, in all animal fluids.

Many chemists have observed, in their analysis of animal fluids, that the alcoholic solution when evaporated leaves a yellow, deliquescent extractive mass. Of late, more attention has been paid to this extract, and if I mistake not, it has been considered as a single substance, and has received the name of *osmazome*. One of the component parts of this extract is *lactate of soda*, and the other, with which it is intimately combined, is an animal matter that may be separated by means of tannin. To prove the presence of lactic acid, dissolve the whole in alcohol, and add a mixture of sulphuric acid much diluted with alcohol, as long as there appears any precipitate, which is sulphate of potash or soda. Digest this spirituous solution (which contains muriatic, sulphuric, lactic, and sometimes phosphoric acid) with carbonate of lead, and all the above acids will unite with the oxyd of lead, but of these only the lactate will be soluble in alcohol. Decant the alcoholic solution of lactate of lead, separate the lead by a stream of sulphuretted hydrogen gas, and by evaporating the clear liquor, the lactic acid will remain in the state of an acid syrup.

table by tannin and by muriate of mercury, and which appeared to me to be extracted from the albumen by the boiling water, during its coagulation, and to be analogous to the substance obtained by boiling fibrin with water.

We have been told, that the blood contains much alkaline and earthy phosphates. I coagulated a large quantity of serum, and thus procured a good deal of the residuary uncoagulable fluid. This I mixed with barytic water, which after a time gave a slight precipitate, soluble in muriatic acid. Some of the same serum mixed with lime-water, was not clouded. It follows from this, that the blood contains no sulphuric acid, and only a vestige of the phosphoric. In my Treatise on Animal Chemistry, I have endeavoured to prove, that the phosphates, as well as the lactates are always produced by the spontaneous decomposition of animal substances, and that the small quantity of each which is found in the blood, is carried thither by the absorbent system, in its progress to the secretions, through which it is discharged from the body, and hence the secretions contain always a much larger proportion of these acids.

Not to be too diffuse, I shall pass over the description of the methods I employed, to ascertain the respective proportions of the contents of the serum, and shall only give the results:

A thousand parts of serum, I find to consist of

Water	-	-	-	-	905.00
Albumen	-	-	-	-	79.99
Substances soluble in alcohol, viz.					
Lactate of soda, and extractive	}	8.74			
matter			-	-	6.175
Muriate of soda and			-	-	2.565
potash					
Soda and animal matter soluble	}	1.52			
only in water			-	-	
Loss	-	-	-	-	4.75
					<hr/> 1000.00

I washed the albumen well in this experiment, digested it in muriatic acid, and then burnt it to ashes, which were almost exactly equal in quantity to the ashes produced by the combustion of the same weight of colouring matter. But the ash of the albumen was white, and did not shew a particle of iron. I found a trace of soda, but the greatest part was phosphate and carbonate of lime, with a little magnesia. It is clear, therefore, that the earthy salts found in the ashes of coloured blood had not been dissolved in the blood, nor even existed as salts in the blood, from which they were obtained by means of combustion. Hence we may conceive, how the blood can produce and deposit in the animal economy, the earthy phosphates, which, however, are not soluble either in pure water, or in the blood; and hence too we may infer, that the production of bone cannot be considered as a simple crystallization of a salt, con-

veyed by the blood in a state of solution, but requires us to suppose the decomposition of the animal matter of the blood, as well as in any other secretion.

All the authors who have written on the blood, assert that gelatine is one of its component parts. This, however, is a mistake, and arises from the gelatinous appearance of the albumen, as I have never been able to detect a particle of gelatine in blood; and, as far as my researches extend, I have found gelatine to be a substance altogether unknown to the economy of the living body, and to be produced by the action of boiling water on cartilage, skin, and cellular membrane, substances which are totally distinct from fibrin and albumen.

Of Human Blood.

The blood of man perfectly resembles in composition that of the ox, but the coagulum of human blood is more easily decomposed by water, and the fibrin thus obtained is more transparent. When dried, it amounts to no more than 0.75 from 1000. parts. Human fibrin has the same chemical properties with that of the ox, but is more readily incinerated: the white ash consists of the phosphates of lime and magnesia, a little carbonate of lime, and soda.

The colouring matter of human blood is also chemically the same with that of ox blood, but is much more easily reducible by fire to the same yellow ash, which seems to shew that it contains

less azote or ammonium. A hundred parts of dried colouring matter of human blood, gave 15. parts of ash, of which 3 parts dissolved in water, and was alkaline, and when saturated with acetic acid, and mixed with muriate of barytes, it left a copious precipitate of phosphate of barytes, soluble in an excess of muriatic acid. I found in this acetic solution, no trace either of muriatic acid or of potash. It appears therefore, that soda and phosphoric acid as well as the earthy phosphates, are products of the combustion. As to the portion of the ash of colouring matter, which was insoluble in water, it consisted of the same substances in nature and in proportion, as that of the ash of the colouring matter of ox blood.

The serum of human blood is composed (according to my experiments) of

Water	-	-	-	-	905.0
Albumen	-	-	-	-	80.0
Substances soluble in alcohol, viz.					
Muriate of potash and soda	6.	}	10.0		
Lactate of soda, united					
with animal matter	4.				
Substances soluble only in water, viz.					
Soda, phosphate of soda, and		}	4.1		
a little animal matter	-				
					<hr/> 999.1

* I cannot refrain here from comparing my analysis, with that made in this country by Dr. Marcet, and given in the second Vol. of these Transactions, page 370.

Human albumen is more easily incinerated than that of the ox, and contains more soda and phosphate of soda. A hundred parts of the dried albumen give twelve parts of calcined ash.

The muriates found in human blood are triple the quantity of those in ox blood, owing doubtless to the salt consumed by man in his food. Human blood also contains a larger proportion of muriate of potash.

On the whole, the great agreement in the composition of human and of ox blood is remarkable, and explains to us the possibility of the phenomena observed in the experiments in transfusion.

General results of the analysis of Blood.

1. Blood is composed of one portion, which is liquid and homogeneous, and of another which is

Dr. Marcet finds the following ingredients:

Water	-	-	-	-	909.0
Albumen	-	-	-	-	86.8
Muriate of potash and soda	-				6.6
Muco-extractive matter	-	-			4.0
Sub-carbonate of soda	-	-			1.65
Sulphate of potash	-	-	-		0.35
Earthy phosphates	-	-	-		0.60

A more perfect agreement cannot be expected in the analysis of substances liable to so many accidental differences, particularly in the quantity of water, which in the blood depends so much on the proportion of liquids taken into the stomach. It is clear that Dr. Marcet's *extractive matter* is impure lactate of soda; and I must also observe, that the sulphate of potash and the earthy phosphates found by him in the ashes of serum, are probably, for the reasons above-mentioned, formed by the process of combustion.

only suspended and spontaneously separates when at rest.

2. The liquid part is a solution of much albumen and a little fibrin, both combined with soda. It also contains some other saline and animal substances, but in very small quantity.

3. The portion which is suspended is the colouring matter. It differs from the albumen chiefly in its colour, and its insolubility in serum. The colour seems to be owing to iron, of which it contains $\frac{1}{3}$ per cent. of its weight, but which cannot be separated from it as long as it continues to be colouring matter. This separation can only be affected by combustion, or by the concentrated acids, both of which agents entirely decompose the substance with which the metal was combined. The colouring matter cannot be artificially produced by uniting albumen with red sub-phosphate of iron.

4. Fibrin, albumen, and colouring matter, resemble each other so closely, that they may be considered as modifications of one and the same substance*. I shall in future call them *albuminous*

* One of the most striking points of difference exists in the property which the colouring matter has of absorbing oxygen, and thereby experiencing a very remarkable change of colour. Serum absorbs very little oxygen, and only in proportion as it is decomposed. Can the iron in the colouring matter give it this property? This is probable; but we shall never arrive at any accurate knowledge of these phenomena, without first analyzing these elements of the animal kingdom with the most

contents of the blood, when speaking of them collectively. These three substances *produce*, when decomposed, but *do not contain* earthy phosphates and carbonate of lime; and, indeed, the entire blood contains in solution no earthy phosphate, except perhaps in too small a quantity to be detected.

5. The albuminous contents of the blood will unite with acids, and produce compounds that may be termed saline; these, when neutralized, will dissolve in water, but separate on adding an excess of acid. The acetous and phosphoric acids however must be excepted, as an excess of either of these forms a compound soluble in water. Nitric acid, digested with the albuminous contents, forms an insoluble compound consisting of the albumen in an altered state, and of the nitric and the malic acids. This property of combining with acids is retained in some instances by the albumen after it has undergone the changes produced in the secretory organs; as, for instance, in the peculiar matter of the bile, the curd of milk, &c.

6. The blood contains no gelatine. *

scrupulous exactness. It is then, and not till then, that we may form conjectures; at present they are useless.

* It gives me great pleasure to find that an English chemist, Dr. Bostock, has arrived at the same conclusion, without any previous knowledge of my work, and (owing to a delay in the publication) prior to its appearance. See Dr. Bostock's experiments, published in the first Volume of these Transactions.

Of Secreted Fluids.

There exists no problem in chemistry more difficult to solve, than that of the secretion of animal fluids. The circulating fluid is carried to the organized laboratory which nature employs, no foreign ingredient is added, no chemical re-agent is interposed, and yet the fluid which flows from these organs has acquired chemical properties, which render it decidedly different from the common circulating mass. Not only is the chemical agent which produces these changes unknown to us, but we shall in vain search for any analogous chemical operation. It is doubtless easy to conjecture, that it is by the influence of the nervous system, that this decomposition of blood into the secreted fluids is effected; but what is this influence? If electric, how can it be brought to accord with our present knowledge of electric agency? But avoiding vain conjectures on a subject which perhaps will ever remain a mystery, let us determine from the knowledge we already possess, the chemical nature of the materials of their products. In proportion as we acquire light on the nature of the former, the analysis of the latter becomes more and more interesting, and much may be done by a judicious comparison of the one with the other.

There are two classes of secreted fluids; namely, *the secretions*, properly so called, or the fluids intended to fulfil some ulterior purpose in the animal

economy; and the *excretions* which are directly discharged from the body. The fluids of the former class are all alkaline; and of the latter, all acid. The excretions are the urine, the perspired fluid, and the milk. All the other fluids appear to belong to the former class.

The alkaline secreted fluids may be divided into two very distinct species. The former of these contains the same quantity of water as the blood, so that the change induced by the nervous influence, seems to be confined to that of altering the chemical form of the albuminous materials, without affecting their relative proportion to the water and other substances dissolved in the blood. The bile, spermatic fluid, &c. are of this kind. The latter species consists of fluids in which the influence of the nervous system has separated a large portion of the albuminous matter, and left the remaining liquid proportionally more watery. The saliva, the humors of the eye, and the effused serum of membranes are of this species; and in these the quantity of salts, and in general also of alkali, is the same as in the blood.

The influence of the chemical agent of secretion is therefore chiefly spent upon the albuminous materials of the blood, which seems to be the source of every substance that peculiarly characterizes each secretion, each of which is *sui generis*, and is its principal constituent. All the other parts of the

secretion seem to be rather accidental, and to be found there only because they were contained in the blood out of which the secretion was formed.

Therefore in examining the secreted fluids the chief attention should be paid to the peculiar matter of the fluid, which varies in all. This matter sometimes retains some of the properties of albumen, at other times, none; and hence an accurate analysis shewing the quantity and nature of this peculiar matter is above all to be desired.

If the several secretions be supposed to be deprived of their peculiar matter, and the remainders analyzed, the same residue would be found from them all, which also would be identical with the fluid separated from the serum after its coagulation. Thus we should find, first, a portion soluble in alcohol, consisting, as has been already shewn, of the muriates of potash and soda, of lactate of soda, and of an extractive animal substance precipitable by tannin: and secondly, of a portion soluble only in water, containing soda (which acquires carbonic acid by evaporation, and is separable by acetic acid and alcohol) and another animal substance, not extract, precipitable from its solution in cold water both by tannin and by muriate of mercury. Sometimes a vestige of phosphate of soda will also be detected.

The excretions are of a more compound nature.

They all contain a free acid, which is the *lactic*, and in the urine this is mixed with the uric acid. Urine seems to contain only a single peculiar characteristic matter; but milk has as many as three, namely, butter, curd, and sugar of milk, which, however, seem to be produced by different organs that mingle their fluids in the same receptacle. The perspired fluid appears to have no peculiar matter, but to be a very watery liquid with hardly a vestige of the albumen of the blood, and, in short, is the same as the other excretory fluids would be when deprived of their peculiar matter. If we suppose this matter taken away from those excretions that possess it, the remaining fluid will be found to have properties very different from the fluid part of the secretions, when equally freed from their peculiar matter. That of the excretions is acid, contains earthy phosphates, and when evaporated, leaves a much larger residue than the fluid of the secretions. This residue is yellowish-brown, of the consistence of syrup, with an unpleasant sharp saline taste of the salts it contains. It reddens litmus, is mostly soluble in alcohol, and this spirituous solution contains the muriates of the blood together with free lactic acid, much lactate of soda (the soda being the free alkali of the blood neutralized by this acid) and the extractive matter which always accompanies this neutral salt. The part insoluble in alcohol contains a distinguishable quantity of phosphate of soda, a little of a similar animal matter to that found in the secretions, and

also the earthy phosphates which were held in solution by the lactic acid, and were precipitated by the action of the alcohol. The urine possesses also a number of other substances, which will be specified when describing this excretion in particular.

Having thus given some general views of the composition of all the secreted fluids, I shall proceed to give a short account of each individually.

1. *Of Bile.*

It is well known that the elder chemists considered the bile as an animal soap composed of soda and a resin. The accuracy of this opinion had often been questioned, owing to the very small proportion of soda; and lately our skilful contemporary Thenard, has published an analysis of bile, in which he gives as its component parts, soda, a peculiar matter named by him *Pieromel* and a resin, which united, produce a fluid that has the taste and other distinguishing properties of this secretion. Nevertheless I am convinced that there is no such resin as Thenard and his predecessors have described. I shall not here relate my experiments on this supposed resin in particular, but shall give the results of my enquiries on the bile itself, which will enable the reader to confirm or reject my opinions according as he finds them founded on accurate experiment.

The substance which is peculiar to bile has an

excessively bitter taste followed by some sweetness; the smell is also peculiar, and the colour in most animals varies from green to greenish yellow. It is soluble in water, and its solubility is not in the least promoted by the alkali of bile, since, when this is neutralized by any acid, the peculiar matter does not separate: it also dissolves in alcohol in all proportions. Like the albuminous materials of the blood of which this peculiar matter is composed, it will unite with acids, producing compounds of two degrees of saturation, and hence, of solubility. The acetous acid, which gives soluble compounds with the albumen of the blood, does the same with the peculiar matter of the bile; and hence this matter is not precipitated on adding this acid to bile, though it falls down on the addition of the sulphuric, nitric, or muriatic acids. It is this sparingly soluble compound of biliary matter with a mineral acid which has been mistaken by many chemists for a resin; since it possesses the external characters of a resin, melts when heated, dissolves in spirit of wine, and is again precipitated (in part at least) by the addition of water. The alkalies, alkaline earths, and alkaline acetates decompose and dissolve it: the former by depriving it of its combined acid; the latter, by furnishing it with acetous acid which renders it soluble in water.

The peculiar matter of bile will also combine with many metallic oxides into a pulverulent mass; and the above described resiniform compound of this

matter and any of the mineral acids often forms with the same oxides a substance like a plaster, resembling in this respect also the true resins.

The degree of insolubility possessed by these compounds of acid and biliary albumen varies both according to the species of animals, and also according to the length of time that the bile has been extracted; for the longer it has been kept, the more solubility these compounds acquire; but in this case I have always found that by pouring in a fresh quantity of acid, and slowly evaporating the mixture, the resinous matter falls down as the supernatant liquor becomes more acid.

The biliary matter may be obtained pure in the following way: mix fresh bile with sulphuric acid diluted with 3 or 4 times its weight of water; a yellow precipitate of a peculiar nature first appears, which must be allowed to subside and be removed; then continue to add fresh acid as long as any precipitate is formed; heat the mixture gently for some hours, and afterwards decant the fluid part, and thoroughlyedulcorate the green resin which is left. This resin reddens litmus, and is partially and sparingly soluble in water. It may be deprived of its acid in two ways: one of them is by digesting it with carbonate of barytes and water, whereby the carbonate is decomposed, and the water forms a green solution possessing all the peculiar characters of bile: the other way is by dissolving it in alcohol

and digesting the solution, either with carbonate of potass or carbonate of lime till it no longer reddens litmus, and then evaporating it to dryness. Either of these methods will give the pure biliary matter, and there are also other ways of obtaining it, which I have described in my work on Animal Chemistry, Vol. II. p. 47.

This peculiar biliary matter when pure, resembles exactly entire desiccated bile. Being soluble in alcohol it might be supposed that it would dissolve in ether, but this is not the case, for ether only changes it to a very fetid adipocirous substance, exactly as it acts upon the albuminous matter of the blood. One circumstance relating to the biliary matter has much surprised me, which is, that it gives no ammonia by destructive distillation. Therefore it contains no azote; but what can have become of the azote of the albuminous matter of the blood? for, no vestige of azote is found in any other of the constituent parts of the bile, nor does bile contain any ammonia.

The following is the result of my analysis of bile.

Water	-	-	-	-	-	-	907.4
Biliary matter	-	-	-	-	-	-	80.0
Mucus of the gall-bladder, dis-						}	3.0
solved in the bile	-	-	-	-	-		
Alkalies and salts (common to all						}	9.6
secreted fluids)	-	-	-	-	-		
							<hr/> 1000.0

2. *Of Saliva.*

The saliva is one of the fluid secretions which contain more water than the blood. When first discharged from the mouth it holds suspended a mucus which is not dissolved in the saliva, but gives it its frothy quality. This mucus gradually subsides from the saliva when kept in a cylindrical vessel, and with more ease when previously diluted, after which the supernatant saliva may be decanted off.

Saliva is composed of

Water	-	-	-	-	-	992.9
A peculiar animal matter	-	-				2.9
Mucus	-	-	-	-	-	1.4
Alkaline muriates	-	-	-	-	-	1.7
Lactate of soda and animal matter						0.9
Pure soda	-	-	-	-	-	0.2
						<hr/> 1000.0 <hr/>

Two of these ingredients require further notice.

The peculiar animal matter of the saliva is obtained by adding spirit of wine to dried saliva, which dissolves the muriates, lactates, &c. The soda which remains in the insoluble portion is then extracted by fresh spirits slightly acidulated with acetic acid. The residue is mucus mixed with the peculiar salivary matter, which last may be dissolved by water, leaving behind the insoluble mucus.

This peculiar matter is therefore soluble in water but not in spirits of wine. The solution in water, when evaporated to dryness, leaves a transparent mass that easily again dissolves in cold water. This solution is not precipitated either by alkalies, or acids, or subacetate of lead, or muriate of mercury, or tannin; neither does it become turbid by boiling.

The *mucus* of the saliva is readily procured by mixing saliva with distilled water, from which the mucus gradually subsides, and it may then be collected on the filter and washed. In this state it is white, and would seem to contain phosphate of lime mixed with it. This mucus is quite insoluble in water; it becomes transparent and horny in the acetic, sulphuric, and muriatic acids, but does not dissolve in them, and the alkalies separate nothing from them. The mucus therefore contains no earthly phosphate, though its appearance would lead to suspect this earthy salt. It dissolves in caustic alkali, and is again separated from it by the acids. A small proportion escapes the action of the alkali, but yields to muriatic acid, and is not separable from this acid by an excess of alkali. The mucus of the saliva is very easily incinerated, and though no phosphate of lime is detected in it by the acids in its natural state, a considerable portion of phosphate appears in the ash after combustion.

Is this mucus secreted in the salivary glands, or is it only the common mucus of the mouth? The latter appears most probable, though I confess that the large quantity of this mucus contained in the saliva, and the great difference between its chemical properties and those of the nasal mucus, throw some doubt on this opinion.

It is this mucus that produces the tartar of the teeth, which at first is only mucus precipitated on the surface of the teeth and adhering to them, but soon it begins to decompose, its colour changes by the influence of the air from white to yellow or greenish, the warmth and moisture of the mouth contribute to complete the decomposition, and the same earthy phosphates which are produced by oxidation and combustion in open fire are here formed and slowly deposited on the surface of the tooth by a slower but a similar process. The tartar is therefore as it were the *ash* of mucus crystallized on the tooth, and this, as is well known, will in length of time form very large incrustations.

I have found it to consist of the following substances :

Earthy phosphates	-	-	-	-	79.0
Mucus not yet decomposed	-	-	-	-	12.5
Peculiar salivary matter	-	-	-	-	1.0
Animal matter soluble in muriatic acid					7.5
					<hr/>
					100.0
					<hr/>

3. *Of the Mucus of mucous membranes.*

I shall premise some remarks on the term *mucus* as applied to animal chemistry. It properly signifies the mucus of the nostrils, but many chemists have extended it to other substances found in the animal fluids, so that Jordan, Bostock, Haldat, and others reckon it among the constituents of these fluids. None of these chemists has considered mucus, used as a general term, as identical with the nasal mucus, or, if they have thought so, it has been a very great error. I must now mention that there is no such principle as the mucus of animal fluids, the substance so considered being in reality lactate of soda mixed with the animal matter that always accompanies it. But if it did exist as a separate principle, some other term should have been used, to distinguish it from the mucus of the nostrils which is very different.

The chemists who have the most attended to the analysis of mucus, have been Messrs. Bostock, Fourcroy, and Vauquelin, but none has given a very satisfactory account of its properties. The two latter chemists, who have published a long memoir on animal mucus, have too much generalized the characters peculiar to nasal mucus, in attempting to extend them to the mucus of the intestines and gall bladder, for example, where they are totally inapplicable.

The mucus of mucous membranes is produced

from the same secretory organ throughout the body, and possesses everywhere the same external characters which constitute *mucus* ; but in chemical properties the mucus of different organs varies considerably according to the required use in protecting these organs from the contact of foreign substances. Thus the mucus of the nostrils and trachea, which is intended to protect these membranes from the external air, differs from that of the urinary bladder which is to preserve this organ from the contact of an acid liquor, or from that of the gall-bladder whose contents are alkaline.

The animal matter peculiar to mucus is the same in all cases, and has the following properties : it is insoluble in water, but is able to imbibe so much of this fluid as to become more or less transparent, semi-liquid or what is termed *glairy*. If in this state it be laid on blotting paper, and the paper changed as it becomes wet, the mucus may be deprived of the greater part of the moisture which it had absorbed, and will then lose most of its peculiar properties. Mucus is not coagulable by boiling, it becomes transparent when dry, and generally resumes its mucous character on adding fresh water, but there is great difference in this property.

The liquid part of mucus, or that fluid which the proper mucous matter imbibes, and to which it owes its fluidity, is the same as the liquid that remains after the coagulation of the serum.

My experiments give the following constituent parts of nasal mucus :

Water	- - - - -	933.7
Mucous matter	- - - - -	53.3
Muriate of potass and soda	-	5.6
Lactate of soda with its accompanying animal matter	- - -	3.0
Soda	- - - - -	0.9
Albumen and animal matter insoluble in alcohol, but soluble in water ; along with a trace of phosphate of soda	- - - - -	3.5
		<hr/> 1000.0 <hr/>

Nasal mucus when just secreted contains a greater proportion of water than above stated. It is very fluid, and gives by evaporation only 0.25 per cent. of solid matter. There is reason to suppose that its peculiar animal matter is first dissolved in the free alkali, but is gradually precipitated as the alkali becomes carbonated by the contact of the respired air. The mucus which I analyzed was of such a consistence that the whole quantity fell out on inclining the vessel that contained it.

The proper mucous matter of the nose has the following properties : immersed in water it imbibes so much moisture as to become transparent, excepting a few particles that remain opaque : it may then be separated by the filter from the rest of the water,

and may be further dried on blotting paper till it has again lost nearly the whole of the moisture it had imbibed. Mucus thus dried will again absorb water when immersed in it, and resume its transparency; and this alternate wetting and drying may be repeated an indefinite number of times, but it thus gradually becomes yellowish and more resembling pus. Five parts of recent mucus absorbed by 95 parts of water produce a glairy mass which will not pour from a vessel. When mucus is boiled with water it does not become horny, nor does it coagulate; the violent motion of ebullition rends it in pieces, but when the boiling is discontinued, it is found collected again at the bottom of the vessel, and nearly as mucous as before. I should observe, however, that this mucus naturally contains a little albumen, which must first be extracted by cold water to enable the remaining mucus to exhibit the above mentioned appearances. The nasal mucous matter dissolves in diluted sulphuric acid: when the acid is concentrated, the mucus is carbonized. Nitric acid at first coagulates it, a number of yellow spots being dispersed through the coagulum; but by continuing the digestion it softens and is finally dissolved into a clear yellow liquid containing none of that yellow substance which I have described under fibrin.

Acetous acid hardens mucous matter, but without dissolving it, even in a boiling heat. Caustic alkali at first renders mucous matter more viscous, and afterwards dissolves it into a limpid flowing

liquid. Tannin coagulates mucus both when softened by the absorption of water, and when dissolved either in an acid or an alkali.

The mucus of the Trachea, as far as I have been able to examine, possesses the same properties with the preceding. The first morning expectoration often contains bluish or dark coloured flocculi, which will imbibe 20 times their bulk of water, and sometimes become thereby so perfectly transparent as hardly to be distinguished in the surrounding water. Acids and alkalies act upon them as on nasal mucus.

The mucus of the Gall-bladder much resembles that of the nostrils, but is more transparent, and is always tinged yellow by the bile. When dried it will again soften in water, but loses part of its mucous property. Biliary mucus dissolves in alkali, and its fluidity increases in proportion to the quantity of the latter. If this solution is exactly saturated with an acid, the mixture becomes slightly turbid and of a consistence to be drawn out in threads. All the acids produce with biliary mucus a yellowish coagulum that reddens litmus. The coagulum formed with the sulphuric acid may be restored to its mucous properties by exact saturation with an alkali. Alcohol coagulates this mucus into a very yellow granular mass, to which the mucous property cannot be restored. A similar mass is often found in the adipocirous biliary concretions, and it is re-

markable that it may be produced from mucus by alcohol, as from biliary matter by ether.

Bile itself is often of such a mucous consistence as to be drawn out in threads. This is owing to the presence of mucus dissolved in the alkali of the bile. A very little of any acid (the acetous for example) precipitates the mucus, and destroys the viscosity of the bile. Alcohol has the same effect.

Former chemists seem to have regarded this property of bile as owing to the presence of albumen, the existence of which has been considered as demonstrated by the precipitate caused by adding acetic acid or alcohol. From what I have already mentioned, it is clear that no precipitate produced by acetic acid can be albumen, since the latter is soluble in this acid; and as bile is not disturbed by prussiate of potass or by tannin after the precipitate by acetous acid is removed, this is a proof that no albumen can be contained in bile. The following experiment is conclusive that the supposed albumen of bile is only mucus: mix some bile with very weak sulphuric acid, drain on a filter the yellow precipitate thus formed, and then digest it with a saturating quantity of carbonate of soda and water, and the precipitate will be changed to a mucus which will be more or less glairy according to the quantity of water employed.

The mucus of the Intestines accompanies the ex-

crements, in which it often forms long and transparent filaments. When once dried, the addition of water will not restore its mucous property, but alkalies produce this effect, though without rendering it transparent.

The mucus of the Urinary Passages accompanies the urine, in which it is partly dissolved and partly suspended mechanically. The latter portion is generally too transparent to be distinguished by the eye, but it may be exhibited by letting the urine remain a while at rest, decanting the fluid portion, and drying the mucus on a filter. This loses its mucous property totally by desiccation, and then often becomes rose-coloured, owing to the presence of uric acid, and appears to be crystallized. It softens a little in water. The urinary mucus is easily soluble in alkalies, and is not separated from this solution by acids. Tannin separates it in white flocculi. I shall return to this subject under the analysis of urine.

4. *Of the Fluids of Serous Membranes.*

It is well known that the surface of serous membranes is always moistened by a liquid, which in a state of health is never secreted in quantities sufficient for analysis; it is therefore only during a drop-sical state of these membranes that we can gain any knowledge of its properties. This fluid may be considered as serum deprived of from $\frac{2}{3}$ to $\frac{4}{5}$ of its albumen. It does not coagulate by mere boiling,

but it gradually becomes turbid, and during the evaporation a coagulated mass collects. This appears to be albumen, but it has a sulphur-yellow colour. It is composed of

Water	-	-	-	-	-	-	988.30
Albumen	-	-	-	-	-	-	1.66
Muriate of potass and soda	-	-	-	-	-	-	7.09
Lactate of soda and its animal matter	-	-	-	-	-	-	2.32
Soda	-	-	-	-	-	-	0.28
Animal matter only soluble in water,	}						0.35
with a trace of phosphates							
							<hr/> 1000.00

The fluid whose analysis is here given was that of Hydrocephalus *, which probably approaches

* It gives me much pleasure again to fall in the track of Dr. Marcet's labours, who has analyzed many of these fluids with results so nearly approaching my own as to be a considerable confirmation of their accuracy, particularly as our experiments were made nearly at the same time, and without any knowledge of each other's operations. The following are Dr. Marcet's results.

	<i>Fluid of</i>		<i>Fluid of</i>	
	<i>Spina bifida.</i>		<i>Hydrocephalus internus.</i>	
Water	-	-	-	-
Muco-extractive matter, &c.	988.60	-	990.80	-
Muriates, &c.	2.20	-	1.12	-
Sub-carbonate of soda	7.65	-	6.64	-
Phosphates, &c.	1.35	-	1.24	-
	0.20	-	0.20	-

I may observe that the circumstance of Dr. Marcet's having found a greater quantity of soda is owing to the decomposition of the lactate, as well as to the presence of carbonic acid.

nearer than any other of the morbid effused fluids to the natural state, on account of the short duration of the disease and the little time to which the fluid is exposed to spontaneous change within the ventricles of the brain. The other dropsical fluids are in general more concentrated, which may arise either from the mere consequence of being long kept, or from the transudation of the serum of the blood that always occurs in the last stages of dropsy, and appears also to take place into the urine and cellular membrane.

5. *Of the Humors of the Eye.*

The quantity of these fluids that can be procured is so small that it is not easy to obtain a very exact analysis of them. However, my experiments have shewn me that they bear a very close affinity with the other membranous fluids. Those of the eye are distinguished by being perfectly transparent and colourless; the other membranous fluids having a yellowish tinge. The humors of the eye are not coagulated by boiling. Their composition is as follows :

	<i>Aqueous Humor.</i>		<i>Vitreous Humor.</i>	
Water	-	98.10	-	98.40
Albumen	-	a trace	-	0.16
Muriates and lactates	-	1.15	-	1.42
Soda, with animal matter soluble only in water	-	0.75	-	0.02

The crystalline lens has a peculiar and very remarkable composition. It has been considered as a muscle from the well-known experiment of M. Reil, who, on treating it with nitric acid, discovered in it a peculiar muscular structure; and Mr. Chenevix also found that its density and specific gravity increased towards the center. But its solubility in water is a sufficient proof that it is not a muscle, though to effect this solution it is necessary to break it down, and then it leaves undissolved a small portion of extremely pellucid membrane. This circumstance, added to that of the increasing density towards its center, shews that the structure of the lens is cellular, the cells being filled with pellucid matter of different degrees of concentration.

The composition of the lens I have found to be as follows :

Water	-	-	-	-	-	58.0
Peculiar matter	-	-	-	-	-	35.9
Muriates, lactates, and animal matter,	}					2.4
all soluble in alcohol						
Animal matter soluble only in water,	}					1.3
with some phosphates						
Portions of the remaining insoluble	}					2.4
cellular membrane						
						<hr/> 100.0

The matter peculiar to the lens is remarkable. It coagulates by boiling, and the coagulum has all

the chemical properties of the colouring matter of blood, except colour, which is entirely absent. When burnt, it leaves a little ash containing a very small portion of iron. The liquor in which the coagulum is formed reddens litmus, has the smell of the humors of the muscles, and like them contains free lactic acid.

The perfect achromatic transparence of the lens, notwithstanding its similarity in chemical properties to the colouring matter of the blood, is well worthy of notice. The black pigment of the choroidea is a powder insoluble in water and acids, but slightly soluble in alkalies. When dried and ignited, it burns as easily as a vegetable substance, and the ash contains much iron. From these observations it may well be supposed that the circulating blood is decomposed on the interior surface of the choroidea, leaving there its colouring matter, which is required for the purposes of vision, and conveying the remainder to the inner part of the eye perfectly limpid and colourless. Need I add that the received opinion of the presence of gelatine and albumen in the lens is erroneous? The existence of free lactic acid in the humors of the lens proves nothing with regard to its supposed muscular structure; but only shews the presence of absorbing vessels to convey the products of the spontaneous decomposition of animal matter, one of the most important of which appears to be the lactic acid.

Of the Fluids that compose the Excretions.

I must refer the reader to what I have already observed generally on this subject, and shall proceed to the individual species.

1. The Fluid of Perspiration.

I have not been able to make my experiments on this fluid in any large quantity, the organ that secretes it being extended over so large a surface and seldom affording much at a time. As to what collects in under-waistcoats after some days wearing, it must always be more or less altered by spontaneous decomposition.

I collected on a watch glass a few drops of sweat as they fell from my face, and evaporated them carefully. The yellowish residue had all the appearance under the microscope of the usual mixture of the muriates of potass and soda with lactic acid, lactate of soda, and its accompanying animal matter. It reddened litmus, and dissolved in alcohol, and was without doubt of the same nature as the analogous matter found in the other fluids. The alcohol left untouched a small trace of an animal matter which blackened in the fire, but was in too small quantity to admit of further examination.

Mr. Thenard discovers acetous acid in perspiration, but this acetous acid is produced here, as in his other experiments, from the lactic, by his mode

of operating. It is well known that litmus paper reddens instantly when put in contact with the skin of the living body ; which shews that the acid that produces this effect is not volatile, otherwise it would be evaporated by the dry surface of the body which has always a temperature of 86° to 90° *Fahr.*

2. *Of Urine.*

We possess many analyses of urine, both in a healthy and diseased state, but none of them gives a very extended view of the subject ; and it is clear that the analysis of morbid urine acquires its chief interest from being able to compare it with that of health.

A. *Of The acids of the Urine.*

The acidity of healthy urine has generally been attributed to the phosphoric acid. By the chemical change which the blood undergoes in the kidneys, a large portion of its constituent parts are acidified ; so that the blood which enters alkaline into the renal arteries, returns from the renal vessels loaded with many acids, some of which did not at all exist in the blood at its entrance, and others were present in very minute quantity only. The acids of the urine which do not at all exist in the blood are the sulphuric, uric, and sometimes the benzoic ; the others are the phosphoric and lactic. The muriatic and fluoric acids appear to pass from the blood to the urine without increase in their proportional quantity.

As by the laws of chemical affinity these acids will unite with any alkali that may be present, and saturate themselves with it in the order of the force of their respective affinities, it must follow that where the quantity of alkali is insufficient to saturate all the acids present, the weakest acids must be those that will remain uncombined and will give the urine its acid properties. These therefore must be the lactic and the uric.

1. It is so generally known and so fully proved that the urine contains the *phosphoric*, *muratic*, and *uric* acids, that it is useless to add any thing further on this subject.

2. Urine contains the *fluoric* acid. In my analysis of bones I have found that human and ox bone contain as much as two per cent. of fluuate of lime. It is therefore natural to suppose that the earthy phosphates dissolved in urine, which are chiefly derived from the decomposition and absorption of bone, should also retain the same proportion of fluuate of lime. To prove it, I precipitated a large quantity of urine with caustic ammonia, collected and calcined the precipitate, mixed an ounce of it with as much sulphuric acid, and then heated the mixture moderately in a platina crucible covered with a glass plate prepared for etching. After some hours I removed the glass, took off the graver's wax, and found the lines corroded by the fluoric acid vapour.

Urine saturated by ammonia, filtered, and mixed with muriate of lime gives also a good deal of phosphate of lime, containing no fluoric acid. The urine therefore contains no other fluuate than that of lime.

3. The *sulphuric* acid is also found in urine. The alkaline fluids merely neutralized by acetic or muriatic acid, and then mixed with muriate of barytes, give no indication of sulphuric acid. But if the residue left after the evaporation of these fluids, be first calcined, and the saline part then extracted by lixiviating the ash, and treated with muriatic acid and muriate of barytes, a notable quantity of sulphuric acid is found, produced from the sulphur contained in animal matter. But with urine the appearances are very different. Muriate of barytes added to it forms immediately a copious precipitate of sulphate of barytes; and I have constantly found that the quantity of sulphuric acid in urine exceeds that of the phosphoric acid. Rouelle the elder long ago detected sulphuric acid in urine, but this was considered as an accidental circumstance: I have however very good reason for supposing this acid to be a most essential constituent part of urine. The production of this acid takes place in the kidneys, and the action of these organs resembles combustion in this respect, that part of the constituent elements of the urine, such as the sulphur, phosphorus, the radicals of the alkalies and earths, &c. become oxidated to their *maximum*: and here also the kid-

neys generate some acids with compound bases. The remainder of the blood gives rise to the urea, which being formed from the materials of the blood, ought to contain more azote in proportion as a greater number of the other elements of these materials has been acidified. It would however be incorrect to consider the production of urine as an excretion of the azote which is in excess in the animal economy, because it appears that the amount of its quantity in the constituents of urine is not greater than in the constituents of blood. We might with as much reason consider the kidney as an organ for oxidation; but it is certainly an error to believe that any organ except the lungs has the office of removing one particular element in a greater proportion than the rest.

I at first conceived that the whole of the sulphur contained in the blood was acidified in the kidneys, and consequently imagined that the same change might be induced on a part of the azote, the carbon and the hydrogen. Proust asserts that the urine contains carbonic acid; but it is very difficult to establish the certainty of this fact, because the urea is decomposed by a heat even inferior to that of boiling water, and produces carbonate of ammonia, which is decomposed by the free acid of the urine, and carbonic acid is disengaged. I am rather disposed to believe that urine does not contain carbonic acid, because no bubbles of air are ever seen to form on the sides of the containing vessels: and

if urine still warm be thrown on any substance whatever reduced to powder, such as powdered sugar, no effervescence ensues. Urine is found to contain no nitric acid. If the residuum from evaporation be treated with alcohol, and the undissolved portion, (which must contain all the nitrates of the urine) be exposed to fire, it will exhibit no sign of detonation: although this phenomenon is very perceptible whenever a very small quantity of nitrate of potass or even of nitric acid has been added to the urine. Lastly, I found accidentally that the whole of the sulphur contained in urine is not acidified. I had made use of nitrate of barytes to precipitate the sulphuric acid in urine, and had previously added to the latter some nitric acid in order that the phosphate of barytes might be retained in solution. After having separated the sulphate of barytes, I precipitated the phosphate by ammonia, and after having filtered the ammoniacal liquor, I evaporated it. During its evaporation it deposited small white shining crystals, exceedingly hard, insoluble in water, in acids, or in caustic potass. After subjecting them to many experiments, I at length found them to be sulphate of barytes. In repeating the experiment with muriate of barytes and muriatic acid, in order to prevent the precipitation of the phosphate of barytes, no sulphate of barytes was formed. The production of this salt is the more singular because the nitric acid present was even supersaturated with ammonia. In-

structed by this experiment, I precipitated another portion of urine with nitrate of barytes, and after filtering evaporated it to dryness, and burned the residuum with a fresh quantity of nitrate of barytes. The ashes treated with muriatic acid left a considerable quantity of undissolved sulphate of barytes.

4. *The benzoic acid* is found, according to Scheele, in the urine of infants. I have not been able, in my experiments, to discover the least trace of it, and I much doubt whether it be contained in acidulous urine.

5. *Lactic acid.* It is principally to this acid that urine owes its acid properties: and if I may be allowed to speculate on final causes, I should say that it is destined to hold the earthy phosphates in solution and obviate the dire effects of their deposition in a solid mass. In order to ascertain the presence of this acid, the urine must be evaporated to the consistence of syrup, and treated with alcohol. The substance which remains undissolved is acid, and by the addition of ammonia is decomposed; and the lactic acid combined with the ammonia becomes soluble in alcohol. From its solution in alcohol the ammonia is disengaged by quick-lime, and from the new salt thus formed the lime may be separated by oxalic acid, which leaves the lactic acid dissolved in water. By this process a small part only of the lactic acid contained in the

urine is obtained, the greater part, together with the lactate of ammonia, being carried off by the alcohol.

B. Of the deposit from Urine.

Urine, by cooling, affords a deposit which varies considerably in different circumstances, not only in quantity, but also in external characters. When it is abundant the urine becomes turbid throughout, a grey powder is precipitated, and after continuing for some time at rest, the precipitate is found at the bottom covered with a mucous stratum. The deposit gradually acquires a red tinge, and after some time is found perfectly crystallized. When the urine does not become turbid, there only appears a thin cloud scarcely discernible, which by rest sinks to the bottom or collects in light transparent flocculi, in which there are sometimes formed, after 24 hours, red crystals.

All urine, when newly evacuated, contains a matter suspended in it, which in some degree affects its perfect transparency. This matter is the mucus of the inner coat of the bladder. If the urine, while yet warm, be poured on a filter, it will pass perfectly clear, and the mucus will remain on the filter in the form of transparent and colourless flocculi. The deposit which afterwards takes place in filtered urine is pulverulent and nowise mucous : which proves that it is from admixture with the mucus of the bladder, that the flocculent appearance,

so frequently assumed by the deposit, arises. By drying the mucus loses its transparency, becomes red, and sometimes has a crystalline aspect, which is owing to the presence of uric acid, the crystals of which have a diameter exceeding the thickness of the dried mucus.

If a person after continuing for a long time, either in a standing or sitting posture, without much exercising his muscles, should evacuate urine successively in different vessels, the first portions will contain the largest quantity of mucus, the next less, and the succeeding portions none whatever. This arises from the mucus being heavier than the urine, and collecting in the lower part of the reservoir ; but if, on the other hand, a person be obliged to remain long on his back, and to evacuate the urine in that position, the lowermost portion does not come away first, and it then frequently happens that the whole of the mucus cannot be evacuated, and that a part remains for a long time in the bladder, when, from the disposition of the uric acid to form crystals in the mass of mucus*,

* I have very often observed that when the urine has been evacuated in two portions, of which the one contained mucus, and the other was clear, the latter has afforded no precipitate, while in the former the mucus was found after 12 or 24 hours, to contain numerous red crystals, sometimes of considerable size. It would therefore appear that in urine which does not contain enough of uric acid to form a precipitate by cooling, the presence of mucus favours in some particular way its crystallization.

the latter becomes a nucleus for the formation of calculus. To this circumstance may be ascribed the frequency of this disorder originating during the cure of fractures of the lower extremities.

The cloud which appears in the urine during fever, is in fact merely the mucus of the bladder, which, from the increase of the specific gravity of the urine, subsides more slowly, or sometimes remains suspended in the fluid. The deposition which urine exhibits in diseases, frequently suggests useful indications, and its examination is sometimes of great importance in the practice of medicine. It is necessary, in this inquiry, to distinguish between two different kinds of matter deposited: the one being composed of the materials which are not held in solution, and are mechanically suspended, and the other consisting of those which are dissolved in warm urine, but which separate by cooling. The former contains, in a state of health, only the mucus of the inner coat of the bladder; which, while yet warm, may be separated from the latter by filtration. The mucus that remains forms discrete flocculi, which do not collect together, and which, after being dried, do not recover their original transparency and mucosity by maceration in water. This mucus is in great part dissolved by acetic acid or diluted muriatic acid; but diluted sulphuric acid acts upon it very feebly. It is also soluble by digestion in caustic alkalies.

In *catarrhus vesicæ* the urine is loaded with an enormous quantity of a mucous matter which is suspended in it. This matter is a true mucus, although, in consequence of the morbid affection of the organ which produces it, its characters are different from those of healthy mucus. If it be collected on the filter, in proportion as the water is absorbed, it becomes more and more mucous and viscous; and, during the desiccation, it becomes transparent and greenish. By maceration in water it recovers its mucous character, undergoes after some time an acid fermentation, and acquires a purulent appearance. In a word, the mucus of the bladder, when diseased, approaches more nearly to that of the nose, and differs much in its properties from the secretion in its natural state.

There is still another morbid condition of the urinary passages, in which the urine carries along a matter mechanically suspended in it, and which has so close a resemblance to that produced by *catarrh*, that inattentive practitioners easily confound the one with the other. The urine when filtered leaves a mucous matter on the filter, which however does not become transparent by desiccation, but gives, on the contrary, a white powder appearing only to the touch. This powder consists of phosphate of lime, and the ammoniaco-magnesian phosphate, mixed with the mucus of the bladder. The urine in this disease has lost all its free acid, it does not affect the colour of litmus paper, and I have

have sometimes even seen it restore the blue colour of litmus when it had been reddened by vinegar. In observing this re-action, the paper should be inspected immediately; if it be allowed to dry, it reddens from the decomposition of the ammoniacal salts, and this happens even when the paper is immersed in a solution of neutral muriate of ammonia, or even when the ammonia is in excess. The urine in this disease has also the property of yielding a precipitate by common muriate of mercury, in the same way as during a paroxysm of fever: a circumstance which is owing to the absence of the free acid. *

The secondary precipitate which is formed in urine, which has been filtered while still warm, is pulverulent, and contains, as is already known, the uric acid in abundance. In the first moments after its formation, it is of a greyish white, but it gradually acquires a reddish hue, and the pulverulent

* I once had occasion to treat a man attacked with this disease. I endeavoured by large doses of phosphoric acid to supply the deficient acid in the urine, but without being able to effect any alteration whatever. The dose was at length increased till it purged the patient, when the urine suddenly resumed its natural characters, and became acid, transparent, and deposited uric acid. But these salutary effects disappeared with the purgative one, and they could not be again reproduced. After the phosphoric acid had been employed in vain, the acetic and sulphuric acids were given, but without success. Alkaline remedies had no effect, either beneficial or injurious, and the disease still continues, having produced a great degree of debility in the inferior extremities.

matter assumes at the same time a crystalline form. The change is effected still more quickly when exposed to the immediate contact of air, than when the deposit is covered with urine. The greyish precipitate which is first formed is soluble in caustic alkali, without the evolution of ammonia; but in proportion as it becomes red and crystallized, potass disengages from it ammonia in abundance. It is evident, therefore, that the crystallization of the precipitate depends on the formation of urate of ammonia with excess of acid, which appears to constitute the red crystals which form in urine by cooling. I think I have observed that the mucus is in a great measure concerned in this change in the precipitate, since it takes place more slowly, and in a less degree, in urine which has been filtered. That species of urine which on cooling becomes milky, and appears like a mixture of clay and water, yields about one thousandth of its weight of precipitate.

The deposit, treated with acetic acid, is partly dissolved, and gives a yellowish solution, from which a precipitate is thrown down by carbonate or prussiate of potass, as well as by infusion of galls, but not by the caustic alkalies. The quantity dissolved is greater, and the yellow colour more intense when the urine has not been filtered before cooling; which appears to prove that the substance dissolved by the acetic acid is in both cases mucus, of which a part has been dissolved in the urine, and since precipitated in a state of chemical combination with

the uric acid. It is this compound which is gradually decomposed, and gives rise to the crystallized superurate of ammonia. The deposit contains none of the earthy phosphates. The muriatic acid digested with the deposit, and then saturated with ammonia, precipitates nothing. Subjected to fire, the deposit burns, and leaves at length, and with some difficulty, a very small quantity of a fused ash, which consists of carbonate of soda, proving that the deposit often contains a small quantity of superurate of soda, that insoluble salt which, according to the experiments of Dr. Wollaston, produces the gouty concretions of the joints.

The secondary deposit of healthy urine, therefore, is not uric acid, but a combination of this acid with an animal matter, which appears to be a portion of the mucus of the bladder dissolved by the warm urine. The deposit contains still a trace of superurate of soda, and by spontaneous decomposition there is formed superurate of ammonia which renders it crystalline.

It is to be presumed that uric acid, which is deposited in the bladder and forms calculi, contains this same animal matter, which ought accordingly to be an essential constituent of all calculi formed in the bladder. I have thus found it in two different calculi which I examined with this view. The following is the mode of separating the uric acid

from the animal matter. The calculus is dissolved in caustic alkali, and a precipitate obtained by adding to the solution muriatic acid in excess. The precipitate consists of uric acid; and a combination of the animal matter with muriatic acid, which may be carried off by washing the precipitate freely on the filter. The muriatic compound is soluble in pure water, and is again precipitated by the addition of muriatic acid, or by allowing it to drop into the acid liquor which has passed through the filter. The uric acid remaining on the filter is in a state of purity greater than any that has been hitherto the subject of examination.

C. Analysis of Urine.

I have been at much pains to arrive at as accurate a knowledge as possible of the precise composition of urine, both as to the quantity and condition of its constituents. The task has been laborious, difficult, and often extremely complicated. It would be trespassing on the patience of the Society, were I to attempt at present to give an account of all the details, and such is the nature of an exact analytical investigation that it admits not of a brief recital. I shall therefore content myself with communicating the general result which is as follows :

1000 parts of urine are composed of

Water	-	-	-	-	933.00
Urea	-	-	-	-	30.10
Sulphate of potass	-	-	-	-	3.71
Sulphate of soda	-	-	-	-	3.16
Phosphate of soda	-	-	-	-	2.94
Muriate of soda	-	-	-	-	4.45
Phosphate of ammonia	-	-	-	-	1.65
Muriate of ammonia	-	-	-	-	1.50
Free lactic acid	-	-	-	-	
Lactate of ammonia	-	-	-	-	
Animal matter soluble in alcohol, and usually accompanying the lactates					} 17.14
Animal matter insoluble in alcohol					
Urea not separable from the preceding	-	-	-	-	
Earthy phosphates with a trace of fluuate of lime	-	-	-	-	} 1.00
Uric acid	-	-	-	-	
Mucus of the bladder	-	-	-	-	0.32
Silex	-	-	-	-	0.03
					<hr/> 1000.00 <hr/>

With regard to the relative proportions of these ingredients, it is very probable they may vary independently of disease. I believe, however, that in urine they are never very different, unless from pathological causes which materially affect the

I should also observe that in the 17.14 parts of lactic acid, lactate of ammonia, &c. there exists a quantity of water which it is not possible to abstract without the risk of decomposing these substances. The quantity of uric acid always varies according to the individual, and also in the same individual from different circumstances which have little influence on health. In the above analysis it was determined from urine which became turbid throughout during its cooling, and which during its deposition resembled water mixed with clay.

The earthy phosphates contain much more magnesia (as much as 11 per cent.) than in the bones or the ashes of blood. Of the cause of this I am ignorant; but I have likewise found much more potass in urine and in milk than in the blood.

The silex was not detected by the combustion of dried urine: for in this way it might have been considered as a constituent of some animal matter dissolved in the urine. I discovered it by treating evaporated urine with alcohol, then with water, and afterwards with muriatic acid, which left the undissolved silex in the form of a grey powder, which fused with soda produced a transparent glass, and which by the decomposition of the glass was converted into the gelatinous state. The water we drink, and which supplies the continual waste of that element by perspiration and by urine, always contains silex, which appears not to separate from

it in the body, and which thus makes its exit in the same state in which it entered. It is evident that this earth should be found dissolved in the other animal fluids, and that the quantity must vary according to the quantity contained in the water used as beverage.

Milk.

My experiments have chiefly been made on the milk of the cow. The composition of this fluid is exceedingly analogous to that of blood. It consists, like the blood, of a chemical solution, and an admixture of undissolved matter suspended in it. By exposing milk for some days in a shallow vessel to the temperature of 32° Fahr. I separated from it the cream as completely as I could. The lower portion of milk, decanted by a hole at the bottom of the vessel, had a specific gravity of 1.033 and yielded by analysis the following constituents :

Water	-	-	-	-	-	928.75
Cheese, with a trace of butter	-	-				28.00
Sugar of milk	-	-	-	-		35.00
Muriate of potash	-	-	-	-		1.70
Phosphate of potash	-	-	-	-		0.25
Lactic acid, acetate of potash, with a trace of lactate of iron					}	6.00
Earthy phosphates	-	-	-	-		0.30
						<hr/> 1000.00 <hr/>

Cream contains the emulsive matter which is not dissolved, more concentrated and mixed with a portion of milk. This emulsion is easily decomposed by agitation, absorbs oxygen, and the butter separates: the milk becoming by this operation more acid than it was at first. I found that cream of the specific gravity 1.0244 was composed of

Butter	4.5
Cheese	3.5
Whey	92.0

As 92 parts whey contain 4.4 sugar of milk and salts, it follows that cream contains about 12.5 per cent. of solid matter.

It is very remarkable that scarcely any other alkali than potash is found in milk. I have burnt a quantity of dried milk, and have dissolved the muriate of the ashes in spirit of wine, and the alkali left undissolved by the alcohol, neutralized by the sulphuric acid, produced only sulphate of potash. I know not how far this observation is applicable to other kinds of milk, or to milk taken from other individuals.

Cheese, which is destined to be part of the nourishment of the young animal, has very peculiar characters, which, as it would seem, fit it for this office. It admits easily of incineration, affording a white ash which contains no alkali, and which

forms as much as 6.5 per cent. of the weight of the cheese. This ash contains principally earthy phosphates with a little pure lime: but it contains neither alkali nor oxide of iron. Cheese digested with concentrated muriatic acid yields the greater part of its phosphates to the acid, and it afterwards burns without leaving any ash. But the cheese may be precipitated from the milk by an acid without losing its phosphates. It appears then, that the latter are not yet formed, but that a slight affinity only is requisite to their production. We may conclude that nature has thus sought to assist the digestive powers of the young during a period of their lives, in which there exists in the oeconomy the greatest demand for earthy phosphates for the purposes of ossification, which is at that time advancing so rapidly.

Cheese is generally considered as a substance insoluble in water, and yet a great part of it is in actual solution in milk. A solution of it in water may be obtained, if cheese precipitated by an acid and well expressed, be digested with carbonate of barytes or carbonate of lime. The carbonate is decomposed with effervescence, and the cheese quitting the acid is dissolved. The solution is yellowish and resembles a solution of gum. Evaporated to dryness it leaves a yellow mass which easily re-dissolves in water. The solution boiled in an open vessel, becomes covered with a white pellicle, precisely as milk does, and acquires the

smell of boiled milk. The membrane is almost insoluble in water, and appears to be a product by the action of air on the dissolved cheese.

With the mineral acids cheese produces the same combinations as albumen and fibrin, although the neutral combinations are less soluble than those of fibrin. A great excess of acetic acid is required in order to dissolve the cheese, and the neutral combination with this acid appears to be insoluble. Cheese is easily dissolved in alkalies. Its solution in acetic acid as well as in ammonia, becomes covered with a small quantity of cream every time that the cheese has not been well separated from the butter. Alcohol converts cheese into an adipocirous and foetid substance.

Butter and sugar of milk are so well known, that no additional information can result from my experiments on them.