XIX. *On expectorated Matter.* *By* George Pearson, *M. D. F. R. S.*

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THE attention of physiologists has been very much withdrawn, for the last half century, from the consideration of the different states of the circulating and secreted fluids, in consequence of the opinion that the nervous and fibrous or muscular systems can afford satisfactory interpretations of the phenomena of living beings; and on account of the disgust produced by the visionary properties and groundless hypotheses, originating in the humoural doctrines of GALEN. But late experiments have manifested, that various things taken into the stomach can be made at pleasure to produce considerable effects, by impregnating sensibly the blood and urine, as well as the milk, sweat, and perhaps saliva. Further; the fine experiments of Professor COLMAN have shewn, that the contagious glanders may be excited in the ass by the transfusion of the blood of a glandered horse, and the matter from the nose of the glandered ass can produce this disease in the horse or the ass.* Hence I apprehend it is reasonable to expect, that the farther investigation of the properties of the animal fluids will afford gratifying instruction to the Researcher in

* Mr. COLMAN alleges, that there is not a sufficient quantity of blood, in a single glandered ass, to excite the glanders by the transfusion of blood into the horse.

natural science, and important practical information to the Physician.

On the present occasion, I desire the honour of communicating the knowledge I may have acquired, by investigating the properties of expectorated matter secreted by the bronchial membrane. The appearances of this substance serve to regulate the judgment of the Physician concerning several diseases of the lungs; but especially of that of pulmonary tubercles which yearly destroys 120,000 to 140,000 subjects of the United Kingdom. It is fit that I remark, that I do not notice in this paper the ingenious experiments of several learned Chemists, because by so doing I should be led into a detail of too great extent for my design.

The numerous varieties of expectorated matter, according to my observation, may be arranged and characterized under the following seven heads:

I. The jelly-like semi-transparent kind of a bluish hue, excreted in the healthy state.

II. The thin mucilage-like transparent matter, so copiously expectorated in bronchial catarrhs.

III. The thick opaque straw coloured, or white and very tenacious matter, coughed up in a great variety of bronchial and pulmonary affections; especially in that of tubercles.

IV. Puriform matter secreted without any division of continuity, or breach of surface of the bronchial membrane, very commonly occurring in pulmonary consumptions.

V. The matter which consists of opaque viscid masses, together with transparent fluid; or the second sort above stated, with nodules of the third or fourth kind.

VI. Pus from the vomicæ of tubercles.

VII. Pus from vomicæ by simple inflammation of the lungs, and without tubercles.

Other kinds of matter are occasionally coughed up, such as calculi,—masses of self-coagulated lymph—serous fluid—blood itself,—and perhaps the vascular substance of the lungs; but I do not write on these matters, because they either do not belong to any particular recognized disease; or they are rare occurrences in some well known disease, and are too obvious to require description.

§ I. *Sensible, or obvious Properties.*

1. *The jelly-like matter*, as already said, is excreted in the best health, as well as sometimes in disease. It is mostly coughed, or hawked up, in a morning soon after a night's repose, during which it seems to accumulate. A few masses, or nodules, then appear of the consistence of jelly, and of the size of a pea to a hazle nut. It is also at any time liable to be excreted, in consequence of various extraneous matters irritating the fauces, to the amount of a few nodules. It is of a grayish colour or inclining to blue, with black specks; and it is rarely whitish in nodules. The consistence is that of jelly, but of much greater tenacity. It has a barely perceivable taste of common salt, or muriate of soda. It commonly floats on water, but by agitation to disengage air bubbles, it sinks. It has no smell. To the naked eye, or assisted by a single magnifier, this matter seldom appears uniform, but consists of a mixture of opaque and transparent masses of irregular figures. With the compound microscope, spherical

particles were perceived, though few in number, when duly diluted. The presence of an alkali I could in no instance perceive, by means of the usual tests, *namely*, turmeric paper, litmus paper slightly reddened by vinegar, and cloth stained with violet juice; nor was an acid denoted by means of litmus paper, except when I had reason to believe it was derived from various acid substances taken with the food, or drink, adhering to the inside of the mouth and fauces.

2. *The mucilage-like expectorated matter*, according to my observation, occurs much less frequently than the other sorts. It appears suddenly in great abundance in certain bronchial catarrhs. I have seen it to the amount of two, or three pints in twenty-four hours. It is also secreted, but less copiously in paroxysms of spasmodic asthma, and of the hooping cough; and but rarely in pneumonic, or pleuritic inflammations, and in some chronical organic diseases of the heart and lungs.

This matter is a transparent uniform fluid of the consistence of white of egg; or of a mucilage compounded of about one part of Arabic gum, and four or five parts of water. It is colourless,—has a fleshy smell—has a brackish taste. After standing eight or ten hours, a deposit takes place of fibrous, leaf-like, or curdy masses, some of which are seen suspended in the clear fluid. In some cases nodules of opaque thick ropy matter, at certain times, accompany this mucilage-like matter. Under the simple magnifier I perceived irregular figured masses partly in motion and partly suspended. With the microscope, globules were seen; but larger considerably than those of the blood, and much less numerous. With the usual tests there were no indications of alkali, nor of acid,

provided the matter was unmixed with other things. It usually floated, or was suspended in water, when first expectorated; but on standing in the water it fell to the bottom, evidently owing to the disengagement of air bubbles.

By standing exposed to the air in warm weather, it sooner grew fœtid than pus of abscesses; without becoming opaque. Neither could I render it opaque or thicker, by exposure to a stream of oxygen gas for an hour; or by exposure of it in a jar of this gas for a month.

3. *The opaque ropy matter* above-mentioned.

1st. It is secreted most copiously in that very common, and extensively epidemial disease of our climate, the *winter-cough*, occasioned by tubercles, to the amount of half a pint to a pint in twenty-four hours; especially during the winter season for several successive years, and sometimes during the whole of a long life, after the age of forty or fifty years. 2dly. It is often the expectorated matter of the pulmonary consumption of young persons, also occasioned by tubercles, but frequently mistaken for the pus of abscesses or vomicæ. 3dly. It appears, oftentimes, in pneumonic or bronchial inflammation with fever, seemingly being a beneficial discharge; as well as in some instances at the close of a fever without concomitant inflammation of the lungs. 4thly. A severe paroxysm of spasmodic asthma is often terminated in the excretion of this kind of matter. 5thly. A secreted substance of this sort is sometimes expectorated in various chronical organic diseases of the lungs, the heart, aorta, and parts contiguous to the lungs, which occasion difficult transmission of blood through them.

In all these instances the matter by expectoration is of the

consistence of thick cream, or of thin toasted cheese; so tough as to hang in the form of a rope, four or five inches in length, on pouring it from one vessel into another. Its aggregation is such that it is readily detached in large masses from the vitreous surface of vessels. It is not unusual for small black, or reddish spots, and streaks, to appear on the surface of this sort of expectorated substance. A pretty large bulk of it is seldom throughout uniform; but it is frothy, and exhibits opaque masses of various hues with transparent matter interposed. The *colour* is yellowish, straw-coloured, and white, or gray: it also, though seldom, is greenish and bluish. The *taste* asserted by patients, is, in their own terms, various, *namely*, saltish, nasty, faintish, sweetish, luscious, or like that of a sweet oyster,—a sharp or sour taste is the most rare. The only *smell* which I have perceived is that of flesh, but very frequently there is none. When any offensive or pungent smell was perceived, immediately after expectoration, I have always found that it was owing either to the foulness of the vessel in which it was received; or it was from extraneous matters in the mouth, and from decayed teeth.

This opaque viscid substance, being duly diluted with distilled water was examined with microscopes of common, as well as of very great powers: by means of any of them crowds of spherical particles were seen passing to and fro, in currents, not unlike those of the blood; except that they were larger. These globules I could not destroy, nor alter in form, by trituration; nor by long boiling in water; nor by exsiccation, and again dissolving in water; nor even by coagulation with mineral and vegetable acids, with alcohol, with sulphuric ether, or with tannin, and alum; nor by mixture with caustic

alkalies in a proportion which leaves the liquor turbid; nor for some time after the putrefactive process had appeared. But these globules disappear with such a proportion of sulphuric acid as detaches charcoal; or of nitric acid, and of liquid potash, as produce a clear solution: also by charring by fire. It is perhaps superfluous to remark, that these atomic globules are quite different from the air bubbles usually entangled in this kind of matter, as perceived by the microscope; the latter differ much from the former, in being of far greater magnitude—in being less numerous—in being transparent, and disappearing on agitation, or heating the matter, or even by mere standing.

For the most part this expectorated substance swims on water; but by agitation or stirring to disengage air bubbles, or by merely standing, it sinks. Some of the lumps suddenly hawked up, immediately fall to the bottom of a vessel of water. No signs of either acid, or alkali, appeared on the trials of this matter with well known reagents, provided it was free from extraneous matter; but it was apt to betray acidity from things taken with the food or drink.

4. *Puriform matter.* I have seen this matter expectorated in several diseases in the quantity of two or three ounces to half a pint in twenty-four hours, on some rare occasions, without any breach of surface. I believe it would be considered by every one to be *pus*, having the properties commonly admitted to be those of this substance. It will however, perhaps, only be just to call it *puriform*, for the present, as it appears to me probable, that I shall hereafter be able to show that it possesses properties not belonging to pus of abscesses, although in the obvious, or sensible properties, it is similar to

such pus. Accordingly this expectorated matter is not only opaque, white, or yellowish, and as thick as the richest cream, but it also has not more tenacity than cream. It is not apt to entangle air, and therefore it immediately mingles with water, rendering it milky; and presently subsides to the bottom, leaving the water clear, or at least whey-coloured. It appears to the naked eye uniform in its texture; and nearly so under the simple lens: but under the microscope thousands of globules similar to those of the blood are seen, which are indestructible as those above related belonging to another kind of expectorated matter.

The substance, of which I am now speaking, is most frequently excreted in the latter stages of pulmonary phthisis, for many weeks successively. It is taken for granted that this matter is from a breach of surface or ulceration; but on examination after death, such a state was not found, in many instances, under my observation, although the lungs were as usual full of tubercles and vomicæ. This puriform matter is occasionally expectorated in certain other diseases. The last summer my colleague, Dr. NEVINSON, furnished me with several ounces of this sort of substance, but of a greenish hue, and of the consistence of thin cream; which was expectorated by a woman in the third week from the attack of the measles. In a few days she died. On examination of the lungs very carefully, by the excellent house surgeon of St. George's hospital, Mr. DAWES, no ulceration could be discovered in the trachea or in the bronchial tubes; nor were any tubercles, or abscesses found in the lungs. The patient, according to my information, had expectorated more than a pint of this fluid every twenty-four hours for a week before death.

In another hospital case, a man laboured under a cough with spitting of matter, which all who saw it called pus, and as usual it was considered to arise from an ulceration, or suppurated tubercles; but, on examination after death, the disease was ascertained to be condensation of the lungs, to the consistence of liver, with water in the cavities of the chest, and nothing more.

5. *Opaque viscid matter of the third, and perhaps fourth sort*, above distinguished, appearing in nodules, and irregular figured masses, *mixed with transparent slimy matter of the second sort.*

It is not unusual to see the mixture of these two different kinds, from severe fits of coughing in that constant epidemy of the British islands, the winter chronical pneumonia.

Different parts of the bronchial membrane being in different states, may account for the secretion of the two different matters. This seems more probable, than that these different matters should be secreted from the same part; although it is true that the same part does secrete at one period transparent thin slime, and at another an opaque thick matter. The former is occasioned by great irritation of the membrane, and the latter is the effect of a more gradual secretion with much less irritation.

For the sake of brevity, I avoid a further description. The practical application of these observations, however important, would not be suitable in this place.

The sixth and seventh kinds of expectorated substances being secreted after a quite different manner, and being very different in their nature from the preceding five kinds, I shall not give an account of them in this paper.

§ II. *Agency chiefly of Caloric.*

1. No effect of importance is produced by this agent, until the temperature of the expectorated matters is raised to about 150° of FAHRENHEIT's thermometer: then the state of aggregation is evidently altered, the viscidity of each of them being diminished. At about 155°, coagulation begins to be quite evident in the first, third, fourth, and fifth kinds of matter—that is, curdy masses of various magnitudes appear in a milk-like, or whitish liquid. On elevating the temperature to 160° or 170°, a large proportion of curd is formed; but the proportion of the curdy matter to the liquid is very different in different specimens, The viscid texture, or tenacity of the expectorated matters, is by this treatment destroyed. The milky liquid decanted, after standing ten or twelve hours, affords, on evaporation to dryness, about three to four grains of residue from each 100 grains.

This liquid passes very slowly through the paper filter. The filtrated liquor affords scarcely more than one per cent. on evaporation to dryness. By repeatedly boiling in successive portions of water, the whole, as far as I could judge, of a given quantity of the curd might be diffused to form a whitish liquid; which on evaporation to dryness appeared to afford a residue of the same kind (except in containing a smaller proportion of saline substances), as the milky liquid which was separated from the curd on the coagulation of the expectorated matter.

The second kind, called *mucilage-like transparent matter*, does not afford curdy masses at the temperatures abovementioned; but its viscid texture is destroyed, and it becomes a whey-like, or somewhat milky liquid; and, on examination

with a magnifying glass, it appears full of curdy particles.—After this agency of caloric, the expectorated matter is much less prone to putrefaction.

2. Distillation of the expectorated matters to dryness afforded a perfectly limpid water, which had a peculiar smell, but no impregnation with ammonia; nor with any other substance which could be detected, except a little carbonic acid.

The residuary matter in a brittle state of dryness, afforded by evaporation, varied between two and a half and ten per cent. of the expectorated substances. The second kind yielded one thirty-fifth to one forty-fifth of its weight of brittle residue. The first kind afforded one twentieth to one twenty-fifth of residue. The third kind afforded very different proportions of solid residue, according to its consistence, *viz.* one tenth to one eighteenth of its weight. The fourth kind gave one twelfth to one fourteenth of brittle matter. The fifth kind yielded very different proportions of residue, according to the very different proportions of transparent and opaque matter, of which it consisted—it varied between one eighteenth and one thirtieth.

3. All these exsiccated substances on exposure to air, grew more or less moist, or at least were no longer brittle; but became somewhat soft, and, proportionately to the state of moisture, were augmented in weight. The thinner the expectorated matters, the moister and the greater increase of weight they generally experienced. But parcels of the same consistence from different patients sometimes differed much in degree of moisture, on exposure to the air. I have found some parcels of the second and fifth sorts of expectorated substances grow quite moist, and receive an increase in weight of three per cent. If the

residues were kept in close vessels, they remained in a brittle state. Larger parcels of exsiccated matter become more moist than smaller ones of the same kind in the same circumstances.

4. The milky and curdy liquids, which separated from the curdy masses (1) being poured off; and also the curdy masses being by pressure rendered dry; the liquids were evaporated to dryness, but became moist on exposure to the air. The curdy masses were by evaporation rendered brittle, and remained so in the air. The residues of the evaporated liquids were said to taste extremely salt, and the exsiccated curdy matter was tasteless.

5. The milky liquids (4) concentrated by evaporation, did not indicate any disengaged acid, nor alkali to the usual re-agents —By triturating these liquids with lime, a little ammonia was discharged—by trituration with concentrated sulphuric acid, the muriatic acid was disengaged—with phosphoric acid, and also with tartaric acid on trituration and heating, a pungent smell was perceived, somewhat like that of the acetous acid.—On burning to a brown ash the saline residue afforded by evaporation of these liquids, the predominating taste of it was that of muriate of soda. This ash readily melted,—being moistened, it turned turmeric paper to a reddish brown colour, and changed turnsole paper, reddened by acetous acid, to a deep blue—on exposure to the air, it partially deliquesced—the dissolution, by boiling in distilled water, afforded supertartrate of potash on the addition of the tartaric acid; and a red precipitate was occasioned by nitro-muriate of platina.* This incinerated and fused saline residue by other

* The knowledge of this re-agent, I believe, the chemical world owes to Dr. WOLLASTON.

trials, was proved to contain phosphoric acid, and lime; with traces of sulphuric acid, magnesia, iron, and perhaps silica; but the chief ingredients were muriate of soda, and potash.

6. The curdy matter after expression (4) afforded a much smaller proportion of brown ash than the fusible saline residue (5). It required an intense fire for fusion in a platina crucible. The fused mass did not deliquesce, but it grew somewhat moist on exposure to the air. It contained a much smaller proportion of potash than the former fused matter (5); also much less of muriate of soda, but a far larger proportion of lime and phosphoric acid with traces of sulphuric acid, magnesia, oxide of iron, and perhaps silica.

7. (*a*) 15400 grains of the third sort of expectorated matter on exsiccation, afforded 960 grains, that is, one sixteenth of brittle substance, or about six per cent., and of course this kind of matter contained about ninety-four per cent. of water (§ II. 2). This dried matter was reduced to a charred state by exposing it to fire in a WEDGWOOD white crucible. In this process it inflamed, emitted the usual smell of burning animal matter, especially of bone, and swelled prodigiously; at the same time a black oil was compounded rendering the mass soft during the inflammation. I could not distinguish the smell of sulphur, but there was, in one part of the burning, a smell, to my sense, of phosphorus.

(*b*). This charred matter was kept in a state of ignition in a platina crucible, till it no longer remained in a powdery form, but was reduced to a comparatively small bulk of a substance of the consistence of paste in an intense fire. By continuing the fire, the charge at length was fused; and after being kept in a state of fusion to be quite fluid for ten minutes,

the fire being withdrawn, a white, brittle, apparently saline matter, like melted common salt, was easily detached from the platina crucible, which in some places had received a red tinge.

(*c*). The melted matter (*b*) weighed fifty-nine grains: of course, this saline residue amounted to $\frac{1}{26\frac{1}{1}}$ of the expectorated matter, and to one sixteenth of this expectorated matter exsiccated. It tasted only of muriate of soda—it had no smell—it effervesced with acids—it betrayed the presence of alkali to the tests above-mentioned—after a few days exposure to the air, it partially deliquesced—it precipitated supertartrate of potash with tartaric acid, and emitted no ammonia with lime; nor sulphur with muriatic acid discoverable by the most delicate tests.

(*d*). The fused matter (*c*) was boiled with three times its weight of distilled water, in which about one half appeared to dissolve. The clear liquid decanted from the sediment and evaporated, yielded crystals of muriate of soda with a much smaller quantity of spicula, or needle-shaped crystals; and saline matter which appeared under a lens not definitely crystallized. A second boiling of the sediment, with twice its quantity of water, afforded almost entirely muriate of soda. A third boiling gave a few crystals of this salt only, as appeared under the magnifier. A fourth boiling, in an equal weight of water, afforded no saline matter.

(*e*). The saline matters (*d*) amounted to forty-five grains when evaporated to dryness. I collected by means of a tooth-pick, from amongst the cubical crystals, as much as I could of the spicula and uncrystallized saline matter. These parts effervesced and precipitated supertartrate of potash with tartaric

acid, and certainly afforded no soda-tartrate of potash—they also afforded a precipitate with nitro-muriate of platina—being saturated with acetous acid there was still a slight precipitation with muriate of baryt; for without acetous acid, there was a most copious precipitation with this re-agent, but the greater part of the precipitate was dissolved by acetous acid, added so as not to supersaturate it.—Oxalate of ammonia did not occasion a precipitation,—with nitrate of silver an abundant one took place—lime water produced only slight turbidity. The muriate of soda amounted, in this saline mass of forty-five grains, to thirty-five grains, or nearly to one grain in 450 of expectorated matter; the rest was subcarbonate of potash amounting to one grain in about 1540 grains of expectorated matter, with which was mixed a minute proportion, probably, of sulphate and of phosphate of potash.

(*f*). The undissolved matter (*d*) boiled with muriatic acid gave a turbid liquid, but on standing, nearly the whole appeared to have been dissolved; a small proportion of sediment only took place in a transparent liquid, which was boiled till it no longer parted with muriatic acid.—This dissolution being exsiccated grew liquid on exposure to air; and oxalate of ammonia gradually added, produced, as I decidedly ascertained, the precipitate of oxalate of lime.

(*g*). The filtrated residuary liquid (*f*); with muriate of baryt gave immediately a copious precipitation—with lime water there was milkiness produced, and subsequently a white precipitation which did not disappear on adding a small proportion of acetous acid—prussiate of potash occasioned a greenish blue colour without precipitation—succinate of am-

monia produced a milky liquid—no effect was observed from tartaric acid.—There being a precipitation with caustic or pure ammonia, as well as with potash, and with the carbonates of the alkalies, it was supposed magnesia was present: and the dissolution of this precipitate in muriatic acid, and in acetous acid, gave no precipitate with oxalic acid. Some of the muriatic dissolution, previously to precipitation with oxalate of ammonia (*f*), being evaporated to dryness, the residue was ignited; but if magnesia was present, as well as lime, it was in too small quantity to be distinguishable from the lime, by composing sulphate. The precipitate now under examination, was certainly not mere magnesia, for it melted into an opaque globule under the blow-pipe—it was not phosphate of lime, for with sulphuric acid, a somewhat bitter and sour substance was compounded, which afforded a precipitate with ammonia, but none with oxalate of ammonia. It was a phosphate not only on account of its fusibility, but because a curdy appearance was occasioned by the mixture just mentioned, with sulphuric acid, on adding it to lime water. Neither was it soluble, like phosphate of lime, in phosphoric acid. The quantity of this precipitate was too minute for decisive experiments, but from those related, it seems probable that it was phosphate of magnesia, which was dissolved, as will appear presently, in phosphoric acid, and precipitated by ammonia.

(*h*). The residuary liquid (*g*), after the precipitation by oxalate of ammonia, being evaporated to dryness, was easily ascertained to be phosphate of ammonia, with indications of a minute proportion of sulphate.

(*i*). It remains only to notice the indissoluble matter in

muriatic acid (*f*). I found it to grow soft, and the parts to cohere under the blow-pipe, and with a little potash it readily melted into an opaque globule.

8. To obtain a more satisfactory proof of the presence of sulphur, forty grains of charred expectorated matter were kept in a state of ignition in a platina crucible, with another inverted over it to completely exclude the escape of gas, for two hours. After cooling, the smell of sulphuretted hydrogen gas very evident, on the addition of diluted muriatic acid, and even of water only. Silver was tarnished, and paper wetted with liquid acetite of lead was blackened by this gas. In some of the experiments, while the charcoal was burning off from the charred expectorated matter, I perceived the smell of sulphur, and perhaps of phosphorus.

§ III. *Agency of Alcohol of Wine.*

1. (*a*) 2500 grains of desiccated expectorated matter of the fifth sort, § I. 5 being the one twentieth of 50,000 grains of matter previously to evaporation to dryness, were digested in four pints of alcohol of spirit of wine, of the specific gravity of 815, water being 1000. The mixture was exposed at the temperature of 58° to 68° for a month, during which it was frequently shaken. A tincture, of the colour of red port wine, was then decanted from off a blackish sediment. By means of a press, two ounces more of the tincture were obtained.

(*b*). The undissolved residuary matter being exsiccated weighed 130 grains less than before digestion. On exposure to the air, it remained dry, but it became more flexible. It no longer emitted ammonia on trituration with lime.

(*c*). The tincture thus obtained was distilled readily till there remained about five ounces measure in the retort, and what remained seemed to be chiefly water instead of spirit, with such a quantity of matter dissolved in it, as not to afford liquid by distillation, without frequently spirting into the receiver. The residuary liquid was therefore evaporated to the consistence of a soft resin-like extract of a black colour; which had a salt with bitter taste.

The distilled liquid had a peculiar pungent smell, but not that of ammonia, and it neither reddened turnsole paper, nor rendered violet cloth green.

(*d*). The resin-like extract (*c*) weighed 140 grains. It was semi-transparent—dissoluble in water, but not coagulable in boiling water—it grew softer on exposure to air—it was uncrystallizable—it betrayed no signs of alkalescency nor of acidity, except just giving turnsole paper a reddish hue—under the blow-pipe it burnt like matter from animals, and afforded a fused globule, which indicated muriate of soda, and a large proportion of potash, deliquescing very speedily—with lime, it emitted the smell of ammonia—with phosphoric, and also with tartaric acid, on being heated, an acid smell was perceived which I at first mistook for acetous acid, for I soon found that no such acid was present, not being able to detect a trace of any acid in the distilled liquid from these mixtures —on the addition of acetite of lead, a very copious precipitation of fawn-coloured sediment instantly took place, with the smell most distinctly of apples. The decanted liquid of this mixture was found to be chiefly acetite of potash. On dropping diluted sulphuric acid upon the fawn-coloured sediment, it constantly emitted the smell of apples. I could not,

however, satisfy myself, that the small quantity of liquid decanted from off this sediment contained a kind of vegetable acid for the first time apprehended in the fluids of animals; because, first, the quantity of product I possessed was so diminished by many experiments, that I was unable to make what I considered to be decisive trials. Secondly, because in subsequent processes I failed in producing the same apple-smelling liquid. Hence I considered that the supposed acid, which had some of the properties of the malic, only occurred occasionally, or that I had been deceived, and that I had procured nothing more than a little of the acid employed for the decomposition, disguised by mixture with the subject of the experiments. The fawn-coloured precipitate was, no doubt, chiefly muriate of lead. Still the experiments fully demonstrate the presence of potash neutralized, either by an acid destructible by fire and dissoluble in alcohol, but hitherto not disunited from animal oxide, or that an oxide of animal matter alone neutralizes the potash, as will be manifested by the evidence of experiments to be related.

(*e*). Forty-five grains of the residue (*c*) which had been dissolved in alcohol, being burned in a platina crucible, yielded chiefly potash, and half its quantity of muriate of soda.

(*f*). Twenty-five grains of the residue (*c*) were boiled with successive portions of nitric acid, till the oxide of animal matter was decompounded and carried off in the state of gases; and then deflagration took place, leaving subcarbonate of potash with muriate of soda and charcoal.

According to a computation, the 140 grains of resin-like extract (*c*, *d*) consisted of twenty-eight grains of potash, and

eighteen grains of muriate of soda, with an inappreciable quantity of ammonia, and perhaps phosphoric acid, besides the oxide of animal matter, and possibly an acid of an unknown kind.

(*f*). The undissolved matter (*b*) was burned in a platina crucible. It afforded a residue, which I could not render fluid by fire, but only of the consistence of paste. On cooling, it was a brittle gray mass weighing fifty-six grains, somewhat salt and gritty to the taste. It consisted of muriate of soda and phosphate of lime, about twenty-three grains of each,—of potash four grains—of fused matter, which by long boiling in muriatic acid yielded phosphate of lime, muriate of lime, and utterly indissoluble vitrefied matter with traces of magnesia, oxide of iron, and a sulphate.

2. Four thousand grains of expectorated matter of the third kind, page 317, § II. 3 were added to two pints of rectified spirit of wine. By agitation, the spirit became at first milky, but presently it grew clear; little curdy masses appearing, which fell to the bottom as a sediment, being in bulk about one fourth of that of the added expectorated matter.

After a month's digestion, the filtrated liquid, on evaporation, afforded a dry extract-like residue, weighing sixty grains. It grew moist by exposure to the air, but not when kept in close vessels. It consisted of the same ingredients, but in very different proportions, as the residue from distilling and evaporating the tincture, page 323, § III. 2, the present residue containing a much larger proportion of muriate of soda, and oxide of animal matter.

Successive digestions of the same matter afforded less and less saline residue, but nearly the same proportion of oxide

of animal matter for three times, but then no saline matter was afforded, but merely animal matter. The residues of the evaporated tinctures of the subsequent digestions did not, like the first, grow moist, but only softer; and the oxide of animal matter from each of them was no longer coagulable, although afforded by dissolution of coagulated matter. It appeared that the animal oxide was of one kind only, and that the whole of it might be dissolved in alcohol, and thereby become uncoagulable, and more easily dissoluble in every kind of menstruum.

3. If a large proportion, namely, two parts of expectorated matter be mixed with two parts of rectified spirit of wine, the matter is in great part, at least, coagulated, but the spirit is rendered milky. The same is true with regard to other menstrua. The reason is obvious. The coagulation is produced by the separation of water from the animal oxide of the expectorated matter, by the attraction of the alcohol, or of acetous acid for the water; but if there is not a due proportion of spirit or acid, the oxide of animal matter retains so much of the water, as to render the liquid milky. A person accustomed to these experiments may determine pretty exactly by means of them, the proportion of water in the expectorated matter, it being directly as the quantity of spirit or acid requisite to produce entire coagulation in a clear liquid; and the proportion of coagulable animal oxide is, within certain limits, inversely as the quantity of spirit requisite for coagulation.

4. Sulphuric ether, being in many properties analogous to alcohol of wine, I digested three hundred grains of exsiccated matter of the third kind, page 317, in four ounces measure of

this menstruum for a month, in a warm room, during which the vessel was often agitated. Three ounces of a black tincture were thus procured, which, on distillation to dryness, afforded sixty-five grains of soft extract. This extract became a little moist on exposure to the air, and was then a little viscid. It burnt with flame like oil to the state of charcoal; and this again on burning, only left two grains of residue, which consisted of muriate of soda, with indications of alkali, and phosphate of lime.

The undissolved residue also remained soft, and could not be made brittle by evaporation. After inflammation and incineration, the usual products were obtained as from matter which had not been digested. This menstruum had therefore dissolved abundantly the oxide of animal matter, and but a small proportion of the saline and earthy parts.

4. Apparently uniform expectorated matter is not of the same consistence through the whole mass; for a few drops of the opaque kind being shaken in half a pint of rectified spirit of wine, the whole does not dissolve, but it is broken into small curdy particles, which fall as a sediment in a clear liquid, seemingly about one-fourth of the original bulk of the matter.

§ IV. *With Water.*

1. None of the kinds of expectorated matter are readily diffusible through cold water, except the second and fourth, page 316 and 319; and by agitating them some fibrous pieces are usually detached; also on inspecting the water after this diffusion, it appears full of small masses, or motes. On standing, these suspended masses become a sediment; which is the

case, although the proportion of expectorated matter be exceedingly small to that of the water.

2. When very hot water is used, namely, that of the temperature of 190° to 210°, a still greater number of motes are perceivable, especially with a lens, and the water is rendered milky.

3. Brisk agitation is required, for a due length of time, to diffuse the other kinds of expectorated matter through cold water; but a great number of fibrous and membranous pieces appear, whose form cannot be destroyed or only partially, by shaking, in almost any proportion of water. Three drops of ropy and opaque matter were shaken in half a pint of distilled water. About one half of them was diffused; the rest was in the form of small fibrous, leafy, and irregular figured motes; which, on repose, formed a sediment, and remained in that state three months; although in that time the water became highly fœtid, and sometimes in this experiment the sides of the vessel were tinged black.

4. Agitation of these sorts of expectorated matter (3), in a large proportion of water at the temperature of 170° and upwards, produced a greater degree of milkiness, and a greater number of small masses, which could not be dissolved by long shaking. Putrefaction did not take place so soon in these mixtures, as in those with cold water.

5. If the proportion of the last mentioned kinds of expectorated matter be two or three parts to one of cold water, or under the temperature of coagulation, an uniform mixture may be produced by violent agitation, the water being entangled by the viscidity of the matter rather than chemically united.

6. On boiling the mixtures (5), a great part of the expectorated matter is separated in a curdy form, from a milky liquid.

7. If less than two grains of expectorated matter were diffused through five hundred grains of water, no evident precipitation was occasioned by tannin; while with one grain of isinglass jelly, or white of egg, or of serum of blood dissolved in five hundred grains of water, there was an evident precipitation with this re-agent.

8. I could arrive at no useful conclusions, for the distinction of expectorated matter from other coagulable, or from any gelatinous substances by comparative trials with muriate of tin, nitro-muriate of gold, oxymuriate of mercury, acetite of ceruss, and acetite of litharge.

§ V. *Agency of acetous Acid.*

1. Twenty ounces of ropy opaque matter, by being shaken with ten pints of distilled vinegar, were so broken into a fibrous or even vascular form as to exhibit an organized appearance, the bulk being reduced to at least one third of the ropy matter. By repeated agitation and long digestion, the coagulated masses were broken into smaller pieces, but did not appear to be further contracted in bulk, or to dissolve. With some parcels of matter, the vinegar preserved its transparency, with others it became whey-like, the matters being deposited in a curdy state. The mucilage-like expectorated matter, or this mixed with the other kinds, afforded whey-like, or more or less turbid liquids with vinegar.

2. (*a*) The decanted liquid, and the liquid obtained by pres-

sure of the sediments of the last mixture (1), being distilled to about one eighth, the remainder was evaporated to the consistence of a thick extract. The distilled liquid did not appear to have received any impregnation, except what had altered a little the odour. This extract-like residue amounted to one forty-fifth to one eightieth the weight of the expectorated matter, according to the kind of this substance. It varied also according to the proportion of the matter to the acid menstruum.

(*b*). The residue (2, *a*) just mentioned, after digestion a second time, in the same quantity of acid, afforded a smaller quantity of extract-like matter than before.

(*c*). The third digestion afforded still less of this substance.

(*d*). The fourth and fifth digestion gave somewhat less than the immediately preceding one.

(*e*). The sixth digestion yielded nearly the same proportion of extract-like matter as the fourth and fifth.

3. The undissolved matter, after these repeated digestions in vinegar (1, 2), being exposed to fire in a platina crucible, first flamed and partially melted; then became apparently charcoal, which burned away to the state of a brown earth-like substance scarcely $\frac{1}{180}$ of the weight of the substance subjected to fire, and not above $\frac{1}{1600}$ of the expectorated matter by which it was afforded. It consisted chiefly of phosphate of lime, with indications of carbonate of lime, of a sulphate, of a muriate, of silica, or at least vitrified matter, and of oxide of iron.

4. The extract-like matter, from the first digestion of the expectorated matter (2 *a*), by exposure to the air, in a few

days partially deliquesced, affording no signs of alkalescency, but having a peculiar salt taste.

(*a*). A little of this deliquescing part being boiled to dryness, with a large proportion of nitrous acid, on beginning to be ignited, it deflagrated, leaving a blackish saline residue; which soon deliquesced, and being lixiviated, it precipitated supertartrate of potash with tartaric acid, and gave a reddish precipitate with nitro-muriate of platina. The residue also contained lime, for the dissolution in acetous acid afforded oxalate of lime, on the addition of oxalate of ammonia.

(*b*). This extract-like matter (2 *a*), by digestion in rectified spirit of wine, gave a blackish tincture, which being decanted and evaporated, left a residue. This became quite liquid after twenty-four hours exposure to the air. It consisted chiefly of acetite of potash, with an inappreciable portion of muriate of soda, and ammonia neutralized, probably, by phosphoric acid; besides uncoagulable and ungelatinizable oxide of animal substance.

(*c*). The undissolved matter by spirit of wine, just spoken of (*b*), after expression, being desiccated, it remained in a solid state after exposure to the air, only growing a little soft in four weeks time. By combustion, it afforded a difficultly fusible ash, which after fusion was found to consist chiefly of phosphate of lime, muriate of soda, with a little potash; a sulphate, traces of iron, and vitrified matter, which probably contained silica united to the other substances manifested in this fused mass.

5. The extract-like matter, by acetous acid on the second digestion (2 *b*), grew soft, but did not deliquesce on exposure to the air. It was found to differ from the matter obtained

by the first digestion in the same menstruum, in containing a much smaller proportion of potash and muriate of soda, as well as of neutralized ammonia.

6. The extract-like matter, from the third digestion in vinegar (2 *c*), differed from the former, in containing a still much less quantity of the salts just mentioned.

7. The fourth and subsequent digestions (2, *d*, *e*) afforded extract-like substances, which contained scarcely any thing but a very small proportion of earthy phosphates, and indissoluble vitrified matter, produced by incineration and fusion. It did not appear that the oxide of animal matter, dissolved by the distilled vinegar in all the preceding digestions successively, was of different kinds; but it appeared, that its coagulable property was destroyed by dissolution in this menstruum. Accordingly, there is no reason to believe that the whole of this oxide is not dissoluble in the acid here employed, although the requisite proportion may decrease after each digestion, within certain limits.

8. A few drops of opaque ropy matter being agitated in half a pint of vinegar, a number of fibrous masses appear, apparently one fourth or one fifth the bulk of the matter added; and these fibrous forms subsist, notwithstanding continued agitation, totally disappearing only in consequence of long digestion in successive large quantities of this acid.

§ VI. *Some Experiments with different Objects.*

1. To produce a synthetic proof that potash may be neutralized by oxide of animal matter, I triturated ten grains of the exsiccated and coagulated part of expectorated matter freed from all saline substance, with pure potash gradually added,

and a little water. Several grains were in this way united, without any effect being produced by the compound on turmeric paper. More alkali was added till the compound barely manifested the existence of alkali to the test just mentioned. It was then digested in spirit of wine, to which it imparted a deep brown colour, and the tincture being distilled, it afforded a dry extract, which grew moist on exposure to the air, but scarcely affected turmeric paper. On incineration, however, the alkali was denuded, and fusion was produced easily.

An equal portion of the animal oxide, of the same parcel as in the last experiment, was digested in spirit of wine, in the same circumstances as this oxide united to potash. It imparted no colour to the spirit, and the extract obtained was in smaller quantity, than in the preceding experiment. Being evaporated to dryness, the residue did not grow moist, but it became a little soft on exposure to the air. Being exposed to fire, it left an inconsiderable proportion of infusible residue, with barely traces of alkali and muriate.

2. To determine, by a more satisfactory experiment than a preceding one, whether or not acid was united to the potash and evaporable, ten ounces of watery liquid, which separates from the curd on boiling expectorated matter, were evaporated to the consistence of a thin extract. This matter indicated neither acid nor alkali in a disengaged state, but it was ascertained to contain a large proportion of potash combined; and an acid smell was perceived on heating it with phosphoric or tartaric acid. Ten drops of liquid phosphoric acid were mixed with four hundred grains of this extract-like matter, and at a low temperature it was subjected to distillation to become almost a dry substance, but no acid could be detected

in the little liquid which came over, nor did this dry substance indicate any acidity to the usual re-agents—neither on exposure to the air did it, as before the addition of acid, grow moist. Phosphoric acid was further added till it became sensible to the test of turnsole: but neither by elutriation nor distillation could any acid be obtained, except a small portion of the phosphoric acid by elutriation, the rest having united to the potash.

3. To furnish an estimate of the proportion of ammonia, I subjected to distillation, a mixture of a pint of expectorated matter of the fifth kind, *page* 321, with three ounces of well burnt lime, but I could not reckon the ammonia in the distilled liquid at more than two cubic inches, or less than half a grain in weight.

§ VII. *Conclusions.*

1. From the preceding experiments and observations, and from others which I might have related, it does not appear that the various kinds of expectorated matter, *page* 314, differ in the ingredients of their composition, but merely in the proportion of them to one another.

2. It has been shown that expectorated matter consists of coagulable, or, as it is also now frequently termed *albuminous* animal subtance, and of water impregnated with several saline and earthy bodies—that the largest proportion of the animal substance, which may justly be called an oxide, amounts to one twelfth, and in some very rare cases to one tenth of the expectorated matter, reduced to a brittle state by evaporation; and that the smallest proportion of this oxide, in rare instances, amounts to one forty-fifth of the expectorated matter; but that the usual proportions of it vary between one twentieth and one sixteenth of this coagulable oxide to the evaporable

water, that is, between five and six per cent. of the expectorated matter.

3. The impregnating substances have been shown to be Muriate of soda, varying commonly between one and a half to two and a half per 1000 of the expectorated matter—Potash varying between one half and three fourths of a part per 1000—Phosphate of lime about half a part of 1000—Ammonia, united probably to the phosphoric acid; Phosphate, perhaps of magnesia; Carbonate of lime; a Sulphate; vitrifiable matter, or perhaps silica; and oxide of Iron. But the whole of these last six substances scarcely amounting to one part in 1000 of the expectorated matter, it would be useless to estimate the proportion of each of them. It is very probable that the proportions and quantities of these ingredients, vary much more than now represented in different states of disease and health.* It is very probable also, that some of the ingredients may occasionally be absent, and others of a different kind be present, agreeably to the different states, on different occasions of the other secretions.

4. It is manifest that the different states of consistence of expectorated matter, are owing to the proportion of albuminous or coagulable oxide, but I purposely avoid giving an account of the different conditions of health, on which the differences of consistence depend.

5. The thicker the matter, the smaller I commonly found the quantity of saline impregnation. Hence, in sudden and copious secretions of the bronchial membrane, the matter is asserted to be salt, and to feel hot. In such instances, the proportion of coagulable matter was small, but that of the

* In one case, the opaque expectorated matter in a pulmonary consumption having been exsiccated to brittleness, became almost liquid after a night's exposure to the air.

saline impregnations, particularly of the muriate of soda, and neutralized potash so great, that the exsiccated expectorated substance tasted very salt, and presently grew moist, or even partially deliquesced; but the opaque ropy or puriform matter afforded a much larger proportion of exsiccated residue, which was but slightly salt, and generally only became soft on exposure to the air. This property of growing moist depends upon the potash.

6. Each of the human fluids, according to my experiments, contain neutralized potash; at least, this is the fact of the blood, dropsy fluid, pus of abscesses, and pus secreted without breach of surface; the fluid effused by vesicating with cantharides; the urine; and in course in the very abundant secretion from the nose by a catarrh. The alkali being united to oxide of animal matter in these fluids, it is easily demonstrable.

7. Although I think I have discovered many properties by which expectorated secretion may be distinguished from expectorated pus, I shall not speak of them, on this occasion, further than just to observe that the saline impregnation of pus, particularly that of potash, and muriate of soda is in very much less proportion than in expectorated secretion; and hence it does not become moist after exsiccation, on exposure to the air.

8. It has been, I believe, uniformly asserted, that the circulating and secreted fluids are impregnated with soda; that it is especially in the matter secreted by the bronchial membrane. The experiments of others must confirm or disprove mine. It seems, however, much more reasonable, that the human fluids should be found to contain potash than soda, united to some oxide or destructible acid; because the former alkali is daily introduced with the vegetable food, and with the

drink of fermented liquor; and it is as little likely to be destroyed, as the muriate of soda also induced in the very same way. But our food and drink do not, commonly at least, contain the soda united to a destructible acid, or an oxide.

9. It is plain, from the preceding experiments, that expectorated matter belongs to the class of coagulable fluids, and not of gelatinizable, or, as commonly asserted, mucous fluids. It differs from the coagulable fluid, serum of blood, in forming a much thicker fluid with a much larger proportion of water: for serum and also the water of blisters, is quite liquid, although they afford, on exsiccation, one twelfth to one eleventh of their weight of brittle residue, while some kinds of expectorated matter, of the consistence of mucilage, afford only one fortieth of dry residue, and others of the consistence of thin paste, afford only one fourteenth of residue.

10. But for the unavoidable extent of this paper, I should trouble the learned Society with various other conclusions and remarks, especially concerning the *globularity* of expectorated matter, which seems to indicate organization. Although ANTONIUS VAN LEWENHOECK, above a century ago, discovered the globularity of the blood, and even noticed it in other animal fluids, neither he, nor any other person, as far as I know, investigated the subject in any fluid but the blood, till by Mr. HOME's acuteness and industry, at a very early period of life, it was observed in pus. I have in this paper related, that expectorated matter, especially the opaque ropy kind, as well as the puriform, is full of globules, and that, except by such agents as destroy charcoal, they are scarcely destructible. Do these spherical particles consist chiefly of organized carbonaceous matter?