Reid (A. P.)

AN

INAUGURAL DISSERTATION

ON

STRYCHNIA:

PRESENTED TO THE

Medical Faculty of McGill College,

MAY 1st, 1858,

PRIOR TO RECEIVING THE DEGREE OF DOCTOR OF MEDICINE AND SURGERY.

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BY ALEXANDER P. REID.

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TO

William Wright, M.D.,

PROFESSOR OF MATERIA MEDICA IN McGILL COLLEGE,

AND TO THE OTHER

Members of the Medical Faculty of that University,

THE FOLLOWING PAGES ARE DEDICATED,

AS A TRIBUTE OF FRIENDSHIP, AND ALSO OF GRATITUDE

FOR THE GREAT BENEFIT DERIVED FROM THEIR VALUABLE TEACHING,

AND THE MANY INSTANCES OF PERSONAL KINDNESS,

BY THEIR FRIEND AND FORMER PUPIL,

THE AUTHOR.

The Medical Faculty of McGill College desirous of marking their appreciation of the high merits of the Inaugural Dissertation on Strychnia, by ALEXANDER P. REID, M.D., have awarded it the unusual distinction of publication. The approbation, thus bestowed, falls upon the production of a young gentleman who had to contend against several difficulties in its composition. Without the aid of superior directions, limited to a few of the treatises in more common use, and unsupplied with chemical auxiliaries of the more delicate sort, he has yet managed to put forth many originalities, particularly in the experimental department of Toxicology, and to give them such a maturity of elaboration as fits them for practical employment. His Essay is founded upon one to which, in the previous year, was adjudged the premium in the Materia Medica Class of the University. The leisure the author has since enjoyed, and the opportunities afforded him while further pursuing his studies in the chief cities of Great Britain and Ireland, have not been allowed to pass away without being devoted to the work of its improvement.

CONTENTS.

STRYCHNIA.

History.—This alkaloid, called also Vauquelina and Tetanine, was discovered in 1818 by Pelletier and Caventou. It is found in the Strychnos Nux Vomica, S. Ignatia, S. Colubrina, &c. It is for the most part united with another alkaloidal principle, Brucia, and both are combined with an acid, the Strychnic or Igasuric. It is the active principle of these plants, and is the agent that causes the fatal effects in death resulting from ingestion of Nux vomica, Ignatius bean, and of false Angustura bark. Brucia is even said to be merely strychnia combined with coloring matter.

Preparation.—It is chiefly obtained from nux vomica bean. The different Pharmacopœias give a method for its preparation. The most common plan is to make two decoctions of the coarse powder of the seeds, or digest it in water acidulated with sulphuric acid—the latter is the most preferable—and to this lime is added, which combines with strychnic and sulphuric acids, leaving strychnia and brucia free. All fall down. The alkaloids are separated from the precipitate by alchohol; they are again converted into sulphates, and are isolated by ammonia; they are furthermore dissolved in hot alcohol and decolorized, and the solution, upon cooling, deposits the strychnia, while the brucia remains dissolved.

Molyn's method is to subject the powder to fermentation with yeast for 10 days, thereby facilitating the subsequent process. This is proposed on account of the mucilage which the seeds contain, causing the decomposition of the saccharic and gummy constituents, evolving carbonic acid, and forming lactic acid, which, acting on the strychnate, forms the soluble lactates of the alkaloids.

The seeds generally contain one part of the alkaloid in 200, but the St. Ignatius bean yields 1.4 per cent., according to Christison.

I have prepared this alkaloid in a different manner, by adding, to the acidified decoction, iodine dissolved in iodide of potassium. An insoluble compound is thrown down, from which the iodine may be abstracted by liquor potassæ; this, when decolorized, may be crystallized from its solution in alcohol. In this method the iodine may be all saved, as it can be easily separated from the filtered solution. Bromine appears to act similarly to iodine in this respect.

From analogy, I should think that chlorine might be economically used instead of either of the two substances previously mentioned. The great difficulty appears to be its application in the gaseous condition. I have found, however, that by treating the acid decoction with chloride (hypochlorite) of soda, (made by precipitation from hypochlorite of lime and carbonate of soda) which, when washed and dried, is to be acted on by liq. potass., although liq. soda would answer the same purpose, the precipitate appears to dissolve when the alkali is added, but the strychnia falls to the bottom in flocculent masses. It should be collected and decolorized in the usual manner, and then crystallized from alcohol, or from solution of a sulphate as a salt.

In these processes I prefer the hypochlorite of soda formed by precipitating the lime from the solution of the hypochlorite by carbonate of soda. This preparation is far superior to the common article, in being much purer, because when chlorine gas is conducted into solution of carbonate of soda only half of the base unites with the chlorine, the other existing as bicarbonate of the alkali, and thus is rendered so far impure; and in general it is a much weaker compound, on account of the difficulty in causing the chlorine to be absorbed, which is not the case with lime in the form of caustic hydrate. I find it almost impossible to precipitate strychnia in the acidified decoction by the common preparation, although readily affected by the other solution.

While engaged with these preparations, I was led to believe that the chemical constitution of hypochlorite of soda is different from that generally received, and that in reality it is a chloruretted chloride of sodium, or a solution of chlorine in chloride of sodium, with other compounds of these elements existing as impurities from faulty manufacture, thus resembling the ioduretted iodide of potassium. When chlorine is conducted into a solution of soda, chloride of sodium and chlorate of soda are first formed, and then free chlorine remains in the liquid. Hypochlorous acid is also formed, and appears to be due to the action of chlorine on chlorate of the alkali, and not, as has been said, to the union of its oxygen with the haloid radical directly, because combination does not occur unless the elements have been some time acting on one another, and upon the addition of an acid, as the sulphuric, chlorine gas, almost pure, is evolved.

SENSIBLE PROPERTIES.—When pure, strychnia is a crystalline substance—white, inodorous, and intensely bitter; when rapidly crystallized it is granular, but by the spontaneous evaporation of the alcoholic solution it takes the form of the octohædron or four-sided prism. It is fusible, but not volatile. The bitterness is such, that 1 part is distinguishable in 80.000 of water.

CHEMICAL CHARACTERS.—Equivalent weight, 334. Composition, $C^{42}H^{22}N^{2}O^{4}$ (Regnault), $C^{30}H^{16}NO^{3}$ (Liebig). It is very insoluble in water, requiring 6667 parts for complete solution at 50° F., equal to about 14 ounces of water for each grain; of boiling water it requires 2200 parts. It is almost insoluble in absolute alcohol or ether when in its free state, but more soluble in common alcohol; by heating, this property is still farther increased. It is also moderately soluble in fixed and volatile oils. As an alkaloid it saturates acids, and even displaces other vegetable bases, as brucia and morphia, and also some metallic oxides are partly separated from their combinations with acids forming double salts. It is destroyed by a heat under that of redness. Sulphuretted hydrogen is evolved when it is fused with sulphur. It is very soluble in diluted acids, forming salts. The common strychnia is reddened by nitric acid, but if pure is unaffected: the color is due to the action of the acid on brucia.

TESTS.—1st.* It is found crystallized in short prisms, or as a greyish powder with a bitter taste. 2nd. Scarcely soluble in alcohol and water, and slightly so in ether, but readily in acetic acid. 3rd. Heated on platinum foil it burns, becomes charred, evolving a smoky flame and poisonous vapour, leaving a residue of carbon. 4th. Nitric acid reddens it, without evolving nitrous acid. 5th. Soluble in diluted acids, and from a hot solution crystals may be deposited on cooling. 6th. The solution is precipitated by tannic acid or tincture of galls. 7th. Alkalies, as ammonia, give a white precipitate. 8th. It is precipitated yellowish-white by terchloride of gold, whereas morphia reduces gold. The precipitate with gold is not re-dissolved by boiling, but the liquid acquires a pink-red color, and on the other hand morphia gives the metallic gold in powder. 9th. The red color by nitric acid is discharged by chloride of tin. 10th. It is unaffected by sesquichloride of iron or iodic acid and starch; it is thus also distinguished from morphia. 11th. Potash precipitates the alkaloid from its salt, and it is not easily re-dissolved by

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* These tests are taken from Taylor's "Medical Jurisprudence."

excess of precipitants, whereas morphia is only precipitated from a strong solution, and it is easily dissolved by slight excess of potassa. 12th. Strong sulphuric acid produces no change of colour in pure strychnia, but if a drop of solution of bichromate of potash be added, the mixture acquires a crimson hue, passing to deep blood-red; or if, instead of the bichromate, either the the deutoxides of manganese or lead be added, a very nice play of colors is produced, which passes through shades of blue, violet, purple, and crimson, to blood-red. I do not think that the bichromate answers as well as either of the others, because the acid causes a colour with it much like what strychnia produces, and in weak solutions this might be a fallacy that is not liable to be met when the others are used. Morphia causes a green-tinted fluid with these tests. 13th. White tinted precipitates are caused by iodide of potassium, and the sulphocyanide of this same base gives white crystals. Solution of bichloride of platinum gives a yellow powder.

There is a newer test than these, the active agent of which is electricity. When the two poles of a powerful battery are brought in contact in the fluid containing strychnia, placed within a depression on a piece of platinum foil, a series of colours are produced.

In reality we have no good test for strychnia in solution upon which we can rely in difficulty. This was clearly evident in the trial of Palmer for poisoning Cooke by strychnia, where the presence of this alkaloid could not be proved.

Nevertheless strychnia is a substance which has really marked and peculiar chemical qualities: it is a base easily separated from the combination in nux vomica, and by no means hypothetical, like methyl, acetyl, etc. Remembering these facts, and that it forms distinct compounds with numerous and varied elements, that through them, it may be separated from complex mixtures, whether mechanical or even chemical, and that it gives distinctive reactions with various agents at the command of the practical chemist, either as regards colour or precipitate, or both, I commenced a few investigations with regard to its chemical properties, to find if it would not be possible to detect small quantities, and be able to separate it from organic mixtures, by some newer and more certain method than those in vogue. As far as I am able to judge, I have found out a method by which I can accomplish these ends, and likewise detect some of the other alkaloids. It is a very simple one, and I trust will be found useful. I found that by a certain re-agent with which I was manipulating, a deep brick-red or brown-coloured precipitate was thrown down from a solution of strychnia, but caused no change with the mineral acids, sulphuric, nitric, hydrochloric, or phosphoric, nor none with the acetic, oxalic, or hydrocyanic. No similar effect was produced in any metallic solution or compound, and I tried all the common bases, alkaline and mineral, nor in a solution of sugar or dextrine. The alkaloidal precipitate is deposited in all acid solutions (except that of the nitric if strong). It is decomposed when boiled with the other strong mineral acids.

The only objections are, that quinine and veratrine give somewhat similar precipitates, but morphia produces no visible change.

The veratria precipitate may appear similar at first, but becomes of a light yellow colour when washed and dried. That with quinine is very dark brown; whereas that with strychnia is a tint between the other two, or brick-red. Bebeerine causes a precipitate very similar to quinine and very difficult to distinguish from it. Santonine gives no apparent re-action. The strychnia precipitate is easily distinguished by comparison with the others, and more surely by a method to be mentioned in another place.

The re-agent used, and above referred to, was the saturated solution of iodine in a solution of iodide of potassium, diluted so as to present a cherry-red tint. The iodine will not act in the compound state, or I should rather say as an iodide, because it then gives another kind of precipitate, the iodide of strychnia, which is a white crystalline salt.

The ioduretted solution is to be added drop by drop to the strychnia. As each one arrives at the bottom of the test-tube, it appears to be fringed by a dirty-white precipitate, which when agitated, acquires a brownish colour. Upon standing, a sediment of the same tint subsides from this mixture; unless in a very dilute solution, when it remains suspended, causing a muddy appearance. This differs materially from the effect it causes with water; then, only, the drop falls to the bottom, without even tinging the fluid, and when shaken up, gives a transparent solution of the peculiar iodine tinge; no further change resulting as the iodine is soluble in the iodide of potassium which is present.

If the re-agent be added to a strychnia solution, in which blood exists, the colour of the precipitate is masked; but, if much of the alkaloid be present, it can be easily distinguished, and if allowed to stand, will fall to the bottom, and, upon being collected, its nature can be determined.

The bitter infusions give no re-action with the test, and in them strychnia can be detected without any difficulty.

If the strychnia precipitate be acted on by strong sulphuric acid, it becomes brownish-yellow. That with veratria, gives with the same acid, a beautiful play of colours, first yellow, next red, and then violet. Quina and bebeerina similarly acted on become greyish-brown.

Strong nitric acid produces nothing characteristic with either, and there is the same absence of distinguishing change when sulphuric acid and bichromate of potash are used. But, if in place of the last-mentioned salt, binoxide of manganese be used, the strychnia precipitate becomes first purple inclining to red, then reddish-brown; at other times a greater play of colours is elicited, but with veratria, bebeerina and quina nothing remarkable is visible.

Another test previously mentioned, as applied to the solid substance, which I have found yielding valuable information, is sulphuric acid and a solution of bichromate of potash added to a very dilute solution of strychnia. I prepare this test by adding to an ounce of water as much of a saturated solution of the salt just named as will render the whole of a light straw-yellow colour, say about 16 drops, and then about 50 drops of the acid. To a part of this mixture the liquid, containing strychnia, is to be added and then boiled; at first there is no change, but as the fluid becomes hotter, the colour becomes gradually deeper in tint and finally blood-red. If the desired alteration be not brought about, it may be hastened by a few drops of sulphuric acid. If the solution of strychnia be very dilute, it will be better to add the proper amount of acid and salt directly to it and then proceed as in the former case; but sometimes the fluid will require to be boiled for a good while, even several minutes, before any change becomes visible, and sometimes it will not form until it cools, but then it is not generally well marked.

It may be said that sulphuric acid will cause this change by acting on the solution of bichromate, even when no strychnia is present. To effect this, however, both agents must exist in very large quantity, and even then the colour differs much, being lighter and inclining to a rose tint; but if it be merely of the strength mentioned there is no visible change even after prolonged ebullition. This test it will be observed differs from the same application of the same re-agent to solid strychnia in several points, as in the requirement of heat, &c.; and of the two it is the most delicate.

I have not yet found any substance that will give the same result with this mixture that strychnia does. It is bleached by morphia and after a time the green oxide of chrome is precipitated. Veratria causes no change nor does quina. Neither blood, sugar, starch, nor dextrine give any appearances that constitute an objection. Iodine, sugar, and most organic liquids dissipate the colour of the solution. Chloride of lime has the same effect. Santonine, bebeerine, the alkalies, acids, and all others I have tried appear to be equally negative.

If the iodine test be added to the bichromate test, when reddened by strychnia, a dense reddish-brown precipitate falls, but if added to one containing no strychnia a dark green is formed.

Liebig mentions that if chlorine be added to a solution of this alkaloid it causes a white precipitate and that bromine acts similarly. I have found that a watery solution of bromine gives a yellowish tinted precipitate with strychnia, but it is not more than one fourth as delicate as that of iodine, resulting probably from the light colour which is given by it in contradistinction to the brown afforded by the ioduretted solution, neither is there the same opacity of the mixture produced with the former as with the latter. I have not found that solution of chlorine gas gives nearly so well-marked a re-action as that of the chloruretted solution before mentioned. It might have the advantage of decolorizing organic liquid, but as a test is not at all desirable.

Delicacy of Tests.—With the ioduretted solution I can detect one grain in solution in four pints of ordinary water, and in pure water by comparison I can discover the presence of one grain in a gallon of the fluid. In this case the liquid becomes milky from the precipitate being suspended in it, and it is so light that it will scarcely fall to the bottom, and if we allow that the ounce of water weighs 500 grains, then one part of strychnia can be thus detected in 64,000 of water nearly. I have even been sensible of its presence in solutions much weaker than these.

With the bichromate solution test I find it is difficult to distinguish one part in 16,000 of water. This test is most distinctive and can be relied on if the proper change appears, but this will not be brought about if any organic compound be present at the time; even the presence of a little alcohol being enough to mask that of the alkaloid.

Experiments on Animals.—I poisoned a chicken with the cyanide of strychnia. At first I gave it the $\frac{1}{64}$th of a grain and in two hours $\frac{1}{64}$th more; in twenty-four hours it got $\frac{1}{16}$th of a grain, and in twenty-four hours or thereabouts, after it had recovered from the previous effects, I gave it the $\frac{1}{8}$th of a grain, which caused death. I then separately boiled in water, acidulated with sulphuric acid, the contents of the crop, the membrane itself, the intestines, the liver, the lungs, the brain, and the spinal cord. After removing any great excess of the acid by carbonate of lime I tried all the tests for the alkaloid, but failed in getting any reliable result. The bichromate solution was decolorized, and the iodine test gave the appearances to be mentioned in a subsequent page, which rendered it impossible to be certain of the product, the liquids being very high coloured. Tincture of galls gave a precipitate, but that was caused by the gelatine present.

The solutions were then evaporated until almost dry, and this extract digested in strong alcohol for some days. This solution was evaporated also until most of the alcohol had disappeared; to this water was added, which dissolved the salt of strychnia in solution, but threw down some white matter insoluble in that fluid. To the filtered products these tests were applied.

(1). The ioduretted solution. It caused the characteristic precipitate which was proved to be strychnia by sulphuric acid and binoxide of manganese, or Marchand's test, so that no room could be left for doubt. Another portion of this, by a method to be mentioned, yielded the alkaloidal strychnia and was recognised to be such by the tests given from Taylor.

(2). The bichromate test. This gave nothing decided, perhaps from a small quantity of organic matter being present, which threw down the green oxide of chrome. In adding to this the iodine test the strychnia was separated as easily as though it had been a simple solution.

(3). The taste was found to be bitter.

(4). An alkali (potash) did not cause any appreciable precipitate.

(5). Tannic acid produced a white curdy precipitate which on re-solution by sulphuric acid was proved to be strychnia. The evidence of the presence of the alkaloid in the liver was well marked, and also in the intestines, but not to the same extent. But the largest quantity was found in the crop, as might be supposed. This part contained rather a homogeneous mixture, and was quite filled. The diluted acid extract was a tenacious, gummy mass, of a dark colour. The others were much similar.

I also examined the lungs, brain, and spinal cord—each separately—but was not able to detect the presence of the poison.

I afterwards examined the stomach of a kitten poisoned by $\frac{1}{10}$th of a grain of the acetate. It contained bread, meat, and coagulated milk; upon these being similarly treated, as in the first experiment, a thick muddy liquid was separated. To this mixed solution the iodine test was added, and I thought I could detect the peculiar fringed border when first added, but on shaking it up there was nothing distinguishable other than what is seen in most organic mixtures. To this liquor potass. was added, which had no other effect than decolorizing the mixture and decomposing the strychnia compound. In a little while the alkaloid fell down as usual, and was proved to be such by Marchand's test, thus doing away with the trouble of evaporating the solution and then again dissolving. The precipitate was also proved by the bichromate solution test.

Another kitten was poisoned by the double chloride of mercury and strychnia. The quantity given I do not think could have exceeded

$\frac{1}{20}$th of a grain. The contents of the stomach were treated as in the former. The iodine test was added to a small quantity of the filtered products, which caused a change similar to that last described. When the potassa was added all the precipitate disappeared. To render the mixture more liquid, water was added. Nothing was seen for some hours, but gradually a very light flocculent precipitate appeared and gradually sank to the bottom. This was proved to be the alkaloid by Marchand's and the bichromate test. When a precipitate forms after the addition of potassa it appears to be almost distinctive of strychnia.

From the liver of an animal, poisoned with about the same amount of the same salt, several hours after it had been taken, when treated in a manner similar to the others, evidence of the presence of the alkaloid was also procured although I only used about the $\frac{1}{20}$th part of the filtered product. This precipitate was washed three or four times and the play of colours with Marchand's test was very delicate, but yet distinctive. Evidence was also afforded with the bichromate test which became visibly reddened. When instead of the precipitate I used the filtered liquid this solution was decolorized.

I should think, judging from these few experiments, strychnia can be detected in very minute quantities well, when existing in heterogeneous mixtures and in complicated chemical compounds. In the first case mentioned, two weeks elapsed between the death of the animal and the detection of the poison. Strychnia is not easily decomposed at common temperatures. It has even been found in the urine, and in some cases I have boiled the organic mixtures containing it for very many hours without affecting it.

DETECTION OF STRYCHNIA IN ORGANIC LIQUIDS.—The method of procedure in this case is similar in design to that pursued with most other poisons. By boiling the stomach and contents, or any of the viscera, as the liver in water, acidified by sulphuric acid, a liquid may be obtained from which the alkaloid may be separated by evaporation conducted almost to dryness, and then acting on it with alcohol which will dissolve the salt of strychnia. If now the alcohol be driven off, the alkaloid will be left almost pure, as detailed in one of the cases in the last section.

The action of these liquids on the iodine test does not in general vary very much. When first added it appears to separate in flakes, the iodide of gelatine, as if coagulated, and the rest of the fluid is tinged with it; and in a little while there is a precipitate which sometimes very much resembles that with the alkaloid; but when it is not present, liq. potass dissolves them all and decolorizes the fluid, although sometimes heat is required to effect this object, and even if any were to remain it would not give the distinctive re-action with Marchand's test. If the iodine test be added to a warm solution of gelatine a re-action similar to that with strychnia appears; but this is no objection, because when it is boiled it becomes liquid, and again on cooling gelatinizes; and if potassa be added to it, it is readily dissolved and decolorized.

The bichromate solution test is almost invariably decolorized by organic liquids.

The iodine test will not act if the strychnia be in solution in alcohol, because the precipitate is soluble in that fluid; but if it be diluted with water, or the alcohol be separated by evaporation, it will act with its accustomed energy.

The method now most generally used for separating strychnia from organic solids, is to boil them for 15 or 20 minutes in dilute solution of oxalic acid. This is then shaken up with sulphuric ether, which has the property of separating the oxalate of strychnia; and the ether being evaporated, will leave the salt in its crystalline form. But I think it would be more convenient to use chloroform instead of ether, because it has the same property, and from its greater specific gravity, it would remain at the bottom, and could be either separated by decantation or by pouring into a funnel and then allowing the chloroform to run off into a receptacle placed underneath to receive it; but it is evident this would only answer where the alkaloid was present in considerable quantity.

A method much more preferable, and giving less trouble, I have referred to in the previous section. To accomplish this, first make a decoction of the substances in diluted sulphuric acid, and, to the heterogeneous and compound filtered mixture, add the iodine test, this causes an abundant precipitate including the strychnia, then add strong solution of potassa to this, which will dissolve everything except the alkaloid, it only being set free and in this state will fall to the bottom of the test-tube, which precipitate being washed and collected, can have the other distinctive test applied to it. This method has a great advantage, because there will not likely be any loss, having few processes to go through which require filtration.

Action of Test with Nux Vomica.—A simple infusion of the seeds yielded nothing very distinctive, but when acidified by sulphuric acid, the characteristic result was obtained and proved to be so by Marchand's test, and moreover I obtained the free alkaloid by potassa, which on being dissolved in acetic acid, was precipitated by an alkali, tannic acid, &c.

The bichromate test gives with the infusion a green-coloured fluid, caused by the separated oxide of chrome.

If we compare the present method of detecting strychnia in nux vomica seed, with that above detailed, I think the advantage in favour of the latter will recommend it to preference.

As the alkaloid only exists in the seed to the amount of a half per cent, one hundred grains of the latter would be required to furnish half a grain of the former. The powder of the seeds has proved poisonous in doses even as small as fifteen grains (Dr. Traill); in thirty grains taken at two doses (Dr. Christison); fifty grains caused death in two other cases; and as the only method of proving that death was caused by this drug is by detecting the presence of the alkaloid, great difficulties exist in the way of verifying the fact. Taylor in his work on Poisons recommends us to digest the powder in alcohol, and from this obtain an extract which is to be boiled in water with calcined magnesia. The alkaloids being precipitated by the alkaline earth, are taken up by digesting in boiling alcohol, and then obtained from this in the usual way. It may be easily conceived that this process would not be likely to yield the desired product when only from thirty to fifty grains are to be operated upon; whereas by the Iodine test it can be precipitated directly from the diluted acid decoction, and the Iodine separated by Potassa. I should therefore think at least that there would be less room for mistake in the latter method.

STRYCHNIA RE-OBTAINED FROM COMPOUND SOLUTION.—If the compound of Strychnia and Iodine which is obtained in the precipitation by the Iodine test be collected, washed, and dried, a brownish powder is obtained which if it be digested in Liq. Potassæ, the Iodine is abstracted by the alkali (as proved by the starch test) and the alkaloid is obtained as a whitish powder insoluble in either excess of alkali or alkaline Iodide. This may be proved to be Strychnia by its solubility in diluted acids, its bitterness, and the play of colours caused by sulphuric acid and binoxide of manganese or lead. I have found that a strong solution of Potassa is much superior to Liquor Ammoniæ for abstracting the Iodine from the compound powder, the alkaloid being obtained much purer. When Ammonia is used, heat is very frequently required. Strychnia can also be obtained from the reddened solution, obtained by the Bichromate test, by precipitating as usual by the Iodine, and collecting the brownish powder which with Potassa will give the accustomed reactions.

It is remarkable that sulphuric acid and binoxide of manganese will give the play of colours as well with the precipitated Ioduretted Iodide as with the pure alkaloid.

PHYSIOLOGICAL EFFECTS.—1. *On Vegetables.*—It is poisonous to all classes of plants.

2. *On Animals.*—It is equally destructive to animals of every species. Its effects on the vertebrata are very uniform ; although the carnivora are more affected by it than the herbivora, being in this respect similar to belladonna and stramonium—thus, half a grain will kill a dog, but a much larger than a proportional quantity will be required to kill a horse. The bird called the Buceros Rhinoceros is said to eat the Strychnos nuts with impunity.

I placed the $\frac{1}{24}$th of a grain on the tongue of a kitten, it walked about apparently unconcerned for 18 minutes, about that time it had spasmodic contractions of all the limbs, the legs were set out as props to keep it from falling. The whole body became rigid and respiration was rendered impossible by the contractions of the muscles of the chest. In about two minutes it became again quite flaccid, and breathed with apparent ease for a few seconds, when the spasmodic action again commenced. This continued for eight or ten minutes when death supervened. The body remained quite flaccid after death.

I put rather less than $\frac{1}{2}$ of a grain into the cellular tissue of the fore leg of another kitten of the same age : it was not affected for about ten minutes, after which the spasms came on. The contractions of the muscles appeared to be more violent than in the previous case and death happened much sooner. The body was likewise flaccid and not rigid.

A pigeon took about the $\frac{1}{16}$ of a grain on a piece of toast, it flew, away unaffected, but in 15 minutes returned and took $\frac{1}{4}$ of a grain more, after which it remained picking about for four or five minutes when it began to be a little irregular in its movements appearing as though the legs were tied, this increased gradually ; it flew away as usual, but just on reaching the top of a house it fell as if shot, after a while it flew for 20 feet farther when it again fell. The spasms did not appear to come on very often ; finally the head was bent directly round on the back, and the tail became depressed, and the head bent forwards again, and the bill rested on the ground, the eyes closed and it then died. It had also the same difficulty of breathing, and the same want of rigidity after death,—being in all these cases different from the spasmodic fixedness of the muscles after death in the human subject.

3. *On Man.*—Three degrees of operation of Nux Vomica may be admitted. I. Increase of tone and diuresis. II. Rigidity and convulsive contractions of the muscles. III. Tetanus, asphyxia and death.

I. The effects of Strychnia are very similar to those of Nux Vomica. Although I am not aware that it acts as a diuretic, it has been found in the urine, and if so it may produce diuresis. It is undoubtedly a very powerful tonic; as seen in its power of arresting the attacks of ague, and of strengthening the coats of the bowels and preventing constipation.

II. The effects of the alkaloid in the second degree precisely resemble those of Nux Vomica—although a less quantity of the latter is required to cause spasmodic action than of the former, if we be guided by the proportion of Strychnia which is supposed to exist in it. The pulse does not appear to be much affected, although it is said to be increased during the convulsive attacks.

III. The third degree of operation is similar in both, each producing tetanus, asphyxia and death. The lower jaw in the inferior animals does not appear to be so violently closed, as accounts of fatal cases in the human subject would lead us to suspect. It is closed no doubt when there is a general spasm of all the muscles; but when it has a local action, merely, the jaws appear in general to be under the control of the will, because they are opened and closed in the ineffectual efforts to respire, taking in a mouthful of air and trying to force it into the lungs when the respiratory muscles fail to act. The similarity in the physiological effects between Strychnine and Nux Vomica were very well exemplified in the fatal case of John Parsons Cook, which happened in 1856, his symptoms being similar to those described by Pariera: he was unable to turn in bed without bringing on violent paroxysms, or to be handled or even spoken to, without a dread of the fatal spasms coming on. He had to keep perfectly still.

Post Mortem Appearances.—After death in the human subject the body remains very rigid—this was one of the prominent symptoms in Cooke's case. It also existed in the case of a young woman poisoned with Nux Vomica, reported by Mr. Ollier. That this does not occur in the lower animals is generally admitted, which shows that it must affect their muscular systems differently. Venous congestion is observed in all these cases which may be expected as a result of obstructed circulation through the lungs. Occasionally there is a slight redness or inflammation of the alimentary canal, and at times softening of the brain and spinal cord, but these are not very fully substantiated.

Modus Operandi.—When Strychnia is introduced beneath the skin it is a local irritant, although it produces its constitutional effects by absorption or nervous influence. In one of the animals experimented on I found a large space inflamed where I had put $\frac{1}{64}$ of a grain of Strychnia 2 to 3 days previously. When the alkaloid was introduced I moved the skin over the subjacent muscles so that it might be diffused across their surface without being wounded by the knife. I subsequently found that the inflammatory action was only excited where the alkaloid was in contact. There is no doubt but it will act as an irritant in the stomach and cause vomiting, although this symptom is not always present. Pareira says Strychnia is absorbed, and it must be, as it has been found in the urine, and I have detected it in the liver; but I can scarcely believe that it acts only by absorption, because, in all the cases that I examined, I found that when death came on very rapidly the poison remained intact in the stomach, even the colour was unaffected, and this could be easily detected when I used the Ioduretted Iodide, the similar compounds with Bromine, and also the double chloride of Strychnia and platinum, all of which are extremely insoluble preparations. Each of these has a distinct colour and each was detected unchanged, apparently, in the several cases, and in some the dose was very minute. I think that if it were only the exceedingly small quantity which could have been absorbed that acted, death would have scarcely happened so soon. About one-third of a grain caused death in a few minutes, and the greater part by far, as near as it could be judged, still remained within the folds of mucous membrane, rolled up in the bolus in which it was given. In another case, I found the scales of the platinum salt lying along the back of the pharynx, gullet, and cardiac orifice, seeming not even to have passed into the stomach, as it was given in butter, which adhered to the mucous membrane in its passage downwards.

Again, when it is applied endermically, it acts much quicker than when given by the stomach; and if absorbed, it could scarcely be assimilated in so short a time. These insoluble preparations do not cause any inflammation of the mucous membrane of the stomach, nor congestion in any part, in so short a time. It appears to act similarly to Prussic Acid, contact being sufficient. This acid will act even if applied to the unabraded skin in its pure state as well as the conjuctiva,—surfaces which do not absorb as readily as some others. In similarity, Strychnia will act if merely applied to the mucous membrane of the mouth; and this is rather an excretory than an absorbing surface.

From what I have seen, I am led to believe that either of these poisons will act wherever applied, provided the part be supplied with sentient nerves, upon the extremity of which the tonic impression is first made, and transmitted thence through the sensory nerves to the spinal cord. Here the effect communicated must be very powerful, otherwise the cord would not be irritated in such a manner as to excite all the motor nerves proceeding from it with such a deadly result. But the reason why, or how it is done, is a mystery which has not yet been solved.

From appearances, the cerebrum is not, or but little, affected at first; it is so, most likely, towards the close of the scene; because the congestion of the venous system will, by the pressure caused on the cerebrum, affect all the nerves leaving it, and will appear to be narcotic. From what has been said, I think that when it acts as a poison in a very short time, or if a large dose have been given, it acts through the nerves of sensation; and if it be some time in acting, or small doses frequently repeated, then it will cause death by absorption and conveyance to the nervous centres.

It cannot be doubted but Strychnia affects the spinal cord, and that portion of it called the "anterior columns," as proved by Matteuci and Majendie; and that it is not solely due to its local action on the muscles, but that they only obey the nervous stimulus, although it is stated that the alkaloid has been detected in their tissue. It can also be proved in another way that it acts on the cord, because even complete decollation will not prevent the spasms; but they cease at once if a piece of whalebone be passed down the canal so as to destroy the cord. If, however, but a portion be thus injured, then only the muscles that receive their nervous supply from this part will be unaffected by the poison; the part untouched being affected as usual.

Segalas, from his experiments, concluded that the irritability of the heart was exhausted. It has a peculiar action on paralysed muscles which has been differently explained, but not yet satisfactorily. These muscles are generally affected before the sound ones, and sometimes it is the reverse. It is supposed to prove fatal both by exhaustion, and stoppage of respiration from spasm of the respiratory muscles.

USES.—It is chiefly used in paralysis; but should be withheld, if recent and resulting from apoplexy, when the clot is still supposed to exist. There are cases on record in which it has been said to have caused inflammation of the brain when given at an improper period. Nevertheless, it is useful in paralysis resulting from apoplexy, where the clots have become absorbed and the muscles, from long want of use, refuse to obey the nervous stimulus. In these cases, it can do no harm when properly given, because all the parts are in a healthy state; and, when the muscles are excited, they gradually come to acknowledge the nervous sway to which they have been long unaccustomed.

It is also useful in other nervous affections, as Chorea, Epilepsy, Hysteria, Neuralgia, and Hypochondriasis. It has been given in Tetanus without increasing the convulsions. It is also used in Dyspeptic affections as pyrosis and gastrodynia; also in Colica Pictonum combined with morphia, in Prolapse of the rectum, in Borborygmi, in Dysentery and constipated bowels. In the last case, it is used when the retention of the fæces is due to a deficient tonicity of the muscular coat of the bowels. It is contraindicated in febrile states of the system. Dr. Wright (Professor of Materia Medica, McGill College, Montreal) recommends it to be preceded by purgatives, local depletion, and a slight mercurialism, in paralytic affections resulting from apoplexy. He says it is very beneficial in paralysis resulting from rheumatism, or the mineral poisons, as lead, arsenic, &c. He recommends it to be administered locally in amaurosis, as a weak solution applied by way of friction, over the temple, or behind the ear, or to the nucha; or these parts may be first blistered, and then either dusted with the powder or moistened with the solution. He also speaks well of it in Spermatorrhœa, impotence, chronic Diarrhœa, Diabetes; and, as a tonic for persons of sedentary habits, and nervous individuals, he also believes it often is suitable.

Dr. Fraser (Professor of Institutes of Medicine, McGill College) recommends it in cases of deficient tonicity of the whole system, 100th part of a grain, with ten drops of Tinct. Ferri Muriatis, given three times a day. The mixture acts not only as a tonic and neurotic, but also as a hæmatinic, which in these cases is always indicated.

ADMINISTRATION.—As a tonic it should be given in doses of from $\frac{1}{100}$th to $\frac{1}{50}$th of a grain, and as a neurotic from $\frac{1}{16}$th to $\frac{1}{12}$th. It is best exhibited as a liquid combined with an acid, as the acetic, to promote its solubility. When given in the form of pill it is much more difficult to be certain of its equal division. The doses of its salts are similar to that of the alkaloid. It is first to be given in small doses, and by gradually increasing them, the constitutional action may be brought out.

ANTIDOTE.—The contents of the stomach are to be evacuated as quickly as possible, where either strychnia or any of its salts have been taken, because no chemical antidote is known. Probably astringents, as tannin, green tea, infusion of galls, &c., would be the best (Pareira).

Donné regards chlorine, iodine, and bromine as antidotes for strychnia; but of their merits a fuller opinion will be stated farther on.

Emmerst, a German author, says that vinegar and coffee increased the poisonous effects of nux vomica bark. Narcotics may be employed to relieve the spasms, as opium and conium. Conia, being the counterpart of strychnia, has been supposed to be a physiological antidote. Pareira applied some of it to a wound in a rabbit affected with tetanus resulting from strychnia. The spasms ceased, but the animal died. Buchner has recommended ether and oil of turpentine. When by the endermic use of strychnia it has acted too powerfully, acetate of morphia applied to the same part has given relief. Dr. Simpson says that chloroform delays and even prevents the spasms of strychnia, and I think that this will be the most convenient and efficacious of any.

I have enquired into the antidotes mentioned by Donné; and first, as regards chlorine, I do not think that this agent would answer a very good purpose, as it would be difficult to administer, and the affinity existing between the principles is not so great as to hold out much chance of success. If used by inhalation it would act merely as a stimulant and not as a chemical antidote. It could not act chemically, because both the chloride and chloruretted chloride are fully as powerful as the pure alkaloid itself.

Iodine, however, we must not pass over so lightly, for seeing the very insoluble substances which is formed with it, we would *a priori* consider it of much importance; but this insoluble precipitate is as powerfully poisonous as the alkaloidal base. I gave a kitten the $\frac{1}{12}$th of a grain of strychnia, dissolved in acetic acid, and immediately afterwards $\frac{1}{2}$ a drachm of the ioduretted solution, nevertheless the kitten died in the usual time and with the ordinary symptoms.

It may be objected to by saying that it was not so administered that the antidote might come in contact with the poison; but to answer this I precipitated some strychnia with the iodine compound, washed and dried it. I then gave about one-third of a grain of this. The spasms, however, came on in the usual time, and with the accustomed severity, and proved fatal. After examining the stomach I found the particles adhering around the cardiac orifice, and scarcely a trace in any other place. About $\frac{2}{3}$ of what was given was found rolled up in the bolus in which it was taken, and not in contact with the walls of the stomach at all. And hence but a very small quantity of the poison acted. Judging from this fact, iodine can scarcely be supposed to be a chemical antidote, and for it to act physiologically is almost impossible. From the activity of the agent opposed to it, for to be of any use, it should act as quickly as the alkaloid itself.

Bromine is the next mentioned; and to show that it has but little if any more power over the poison, I performed an analogous experiment. I gave about the $\frac{1}{16}$th of a grain of bromiuretted bromide of strychnia, an homologous compound with that of iodine, last referred to. It began to act in twenty minutes, but not violently, and continued to do so every ten or fifteen minutes for some hours. I again gave the animal about the same quantity of the substance in mixture with butter. Fifteen minutes afterwards, the spasms came on with great violence, and death occurred in about five minutes. On examination I found the poison between the folds of the corrugated mucous membrane of stomach. I tried another very insoluble salt of strychnia,—the double chloride of platina and the alkaloid,—but its energy was even greater than that of any of the others.

Since it is so difficult, if not impossible, to get any chemical antidote, I have thought that some agent might be met with which would counteract it physiologically.

Such an agent I expected to find in hydrocyanic acid: it acts in general in a contrary manner to that of strychnia, causing at times rather paralysis than spasm. Accordingly, I placed $\frac{1}{6}$th of a grain under the skin of the back of a cat, and when the convulsions became apparent, and respirations had almost ceased, I poured some of the acid on the same spot. In a few seconds the spasms ceased, and the limbs, before rigid and inflexible, became quite flaccid. The animal appeared to be profoundly narcotised, but it began to respire deeply; the parietes of the chest expanding to the fullest, but the breathing was very slow. It remained in this state for several minutes, but gradually the respirations became weaker, and soon ceased in death. The effects in this case were similar to those mentioned by Pareira, who used conia instead of prussic acid. I tried the acid on others that had taken the alkaloid by the stomach; but on account of the difficulty experienced in introducing the acid into the stomach, its physiological effects were not obtained. However, considering all things, I think, with the exception of chloroform and conium, that prussic acid is the best antidote we have got; but as neither the acid nor conium have been very fully inquired into, their relative merits can scarcely be decided on. Of the two prussic acid has the advantage, that it can always be easily obtained. In its use we should not be too lavish, as it even exceeds strychnia in energy, and should only be exhibited in small quantities at a time, not enough to be directly poisonous. It should, if possible, be given immediately on the ingestion of the alkaloid, or as soon as possible afterwards. It might have the effect of deadening the sensibility of the stomach to the action of the strychnia, and thus allow of time to try the stomach-pump, or emetics if this were not at hand. These latter have not, however, been reported upon very favourbly. In extreme cases, a solution of tartar emetic might be injected into the veins, which would be a very probable means of obtaining the desired result.

If prussic acid only were given, and it were successful in preventing the spasms, its action would be temporary, and should not be trusted to alone. It might possibly have the power, by continual exhibition in small doses, of only allowing a small amount to be absorbed at a time. If it were only given after the poisonous effects became well marked, it would, in all probability, relieve the intense pain which is endured, and thus smooth the path to the grave. It could not act chemically, because the hydrocyanate is fully as powerful a poison as the pure alkaloid.

A great many other antidotes have been recommended, as for example camphor; but its chief benefits are those of a simple narcotic and stimulant. Lard also has been much spoken about in the journals of the day; but it can act only mechanically, and must be taken in large quantities, and before any constitutional symptoms are present. It is easy to conceive that it would be a good mechanical antidote, because it has a consistence which would not admit any powder that it was mixed with, to act with gravity, but rather enclose and keep it in strict incorporation. It is also very difficult to digest, and it would impede the alkaloid being taken up; and furthermore, it would likewise greatly assist emesis by coming up in bulk, carrying with it whatever substances were in admixture with it. The objections to it are, that it must be given in large quantity, and that it has no innate power of chemically mixing with the poison; and this latter is a very serious objection, since the alkaloid, except in solution, tends to lodge in the folds of the mucous membrane.

Olive oil has been recommended, but it can merely act as a demulcent, and would not suspend the poison, and if it were in solution, the oil would float on the top, and thus effectually keep it in contact with the sensitive surface.

Thick mucilage of gum acacia I should think would be very useful, as it would mix with the alkaloid if in solution, and like lard would assist in vomiting; but it is liable to be more speedily digested.

Pastes made of flour or meal of any kind, or even bread made into a paste with water, would I think supply the place of lard, and act nearly as well. These have the advantage of being always procurable, and will unite readily with the poison, either solid or fluid; but they are more readily digested.

SALTS OF STRYCHNIA.—They are for the most part, when pure, very bitter, white and crystalline; alkalies, and their carbonates, give white precipitates in their solutions. Tannic acid precipitates them though gallic does not. They are unchanged by the action of persalts of iron when in solution. I shall describe them under the heads of—1st. The combination with the common or oxyacids; 2nd. With haloid radicals or hydracids; and 3rd. Compounds with the metals.

1. STRYCHNIA WITH THE OXYGEN ACIDS.—These salts are generally more active than the base alone, resulting from their greater solubility, and the small quantity of acid present, because the chemical equivalent of the alkaloid is so high (334), and hence its energy is but little affected by the presence of the acid.

Sulphate of Strychnia.—$\overset{+}{St}\ So^3$ or $(C^{42}\ H^{22}\ N^2\ O^4)\ So^3$. This salt is generally formed in the preparation of the alkaloid, but it is usually obtained by saturating the base with sulphuric acid and crystallizing. It consists of single equivalents of each; and crystallizes from neutral solutions in large quadrilateral prisms, but excess of acid causes them to appear in long thin needles. They generally group together in stars. This latter property I have seen well shewn as the concentrated solution cools from the boiling-point. It becomes opaque on exposure to the air, without losing weight, and may be fused without decomposition. If heated carefully it looses three per cent of water. It dissolves in about ten parts of water at 60° and in less at 212°. According to Liebig it is anhydrous. The effects and uses of the sulphate are similar to that of the alkaloid itself; but is more bitter because more soluble.

Nitrate of Strychnia.—$\overset{+}{St}\ No^5$ or $(C^{42}\ H^{22}\ N^2\ O^4)\ No^5$. This salt is not much mentioned. It is generally prepared by saturating the alkaloid with diluted nitric acid. It crystallizes in radiated tufts of long, light, silky, capillary needles, containing one equivalent of water of crystallization, and is very soluble. It is formed in one of the methods for separating strychnia from brucia. The crystals of the latter salt, adhering to the sides of the vessels containing them, while that of strychnia can be poured off with the mother liquor. The effects and uses are similar to those of the alkaloid alone.

Acetate of Strychnia.—$\overset{+}{St}\ A$ or $(C^{42}\ H^{22}\ N^2\ O^4)\ (C^4\ H^4\ O^4)$. This salt is much more soluble than those just mentioned, and is prepared by saturating the alkaloid with acetic acid, and evaporating to crystallization. Acetic acid being the most ready solvent of this base is generally used for this purpose in preference to the others; and hence the acetate is the most generally used of all the salts. Its effects are of course similar to those of the base.

Strychnate of Strychnia.—This is the native salt of strychnia so to speak. It exists in solution in the decoction of nux vomica, combined with colouring matter and other vegetable principles. It is also in this form that the alkaloid is exhibited in the preparations of nux vomica as the extract or tincture. It is only interesting in being the natural combination: its uses are the same as those of nux vomica.

Tannate of Strychnia.—$\overset{+}{St}\ \mathit{Tan.}$ or $(C^{42}\ H^{22}\ N^2\ O^4)\ (C^{18}\ H^5\ O^9)$. This salt is formed when tannic acid or infusion of nutgalls is added to a soluble salt of strychnia. It is only of importance on account of its insolubility, thus being a test for strychnia. It is soluble in sulphuric, nitric or acetic acids; but insoluble in hydrochloric acid or alkalies. Its uses are the same as those of the alkaloid. Tannic acid is supposed to be an antidote for strychnia. It will act by combining with the strychnia in solution, and thus render it insoluble; but this is not a sufficient power, as we have seen that the compounds of strychnia are not rendered less powerful by insolubility, as has been considered.

CHROMATE OF STRYCHNIA.—$\overset{+}{St}\ Cr\ O^3$ or $(C^{42}\ H^{22}\ N^2\ O^4)\ Cr\ O^3$. This is prepared by adding a solution of bichromate of potash to one of a soluble salt of strychnia. The chromate falls down as an insoluble yellowish powder, which appears like broken down cubical crystals. It is insoluble in water, acetic acid, or alcohol; but soluble in sulphuric, nitric, and hydrochloric acids and aqua ammoniæ. Its uses will be similar to those of the alkaloid.

CARBAZOTATE OF STRYCHNIA.—$\overset{+}{St}\ C^{15}\ O^{15}\ N^3$ or $(C^{42}\ H^{22}\ N^2\ O^4)\ (C^{15}\ O^{15}\ N^3.)$ This is prepared by dissolving Strychnia in Carbazotic Acid. It crystallizes in small, round, needle-like crystals, which are whitish and aggregate in stars. It is very soluble in water, alcohol, sulphuric, nitric and carbazotic acids; but insoluble in ether or ammonia. Its uses will be similar to those of the alkaloid itself.

BENZOATE OF STRYCHNIA.—$\overset{+}{St}\ (C^{14}\ H^5\ O^3)$ or $(C^{42}\ H^{22}\ N^2\ O^4)\ (C^{14}\ H^5\ O^3.)$ This salt is prepared by dissolving the alkaloid in Benzoic Acid. It crystallizes from the aqueous solution in groups of crystals, having a cubical form; many are pointed at the extremity. It is not very soluble in cold water. It has no importance except in being a salt of strychnia, and its uses will likely be similar to those of the base.

GALLATE OF STRYCHNIA.—$\overset{+}{St}\ \mathit{Gal}$ or $(C^{42}\ H^{22}\ N^2\ O^4)\ (C^1\ H^3\ O^5.)$ This is a soluble salt, and is merely worth mentioning, because this acid does not form an insoluble compound with the base like Tannic Acid, and would serve as a means of distinguishing these two acids. Gallic acid might be a negative proof of Strychnia from this property, which few other elements possess. When the aqueous solution is evaporated, the salt is deposited in colourless scales: these appear in the field of the microscope like thin broken glass fragments. I could not distinguish any distinct crystalline form. It is more soluble than the Benzoate, and is prepared by dissolving the alkaloid in Gallic Acid and evaporating until it takes its peculiar form. It is not very soluble in cold water. One thing a little remarkable about the salt is, that both Strychnia and Gallic Acid are very insoluble in water taken separately; but when boiled together they form a very soluble salt, although they will not unite in cold water. Its uses are most likely similar to those of the alkaloidal base.

There are other salts with the Oxygen acids, which have nothing very remarkable about their composition and which are soluble. They are the Lactate, Citrate, Tartrate, Oxalate, Borate and Phosphate. They are all easily prepared by dissolving the alkaloid in each acid respectively and evaporating the watery solution.

2. STRYCHNIA WITH THE HALOGEN RADICALS.—The halogen elements do not unite with the oxide of a metal or alkali; and, reasoning from the same premises, we might say that each of the alkaloids is the oxide of some base with which we are unacquainted in its free state; and it might be supposed, that, when the haloid radical separates from it, oxygen immediately combines with it, forming the common alkaloid. This theory would do very well with most of the alkaloids; but there would be a difficulty with those which do not contain any oxygen at all, and yet unite with the oxygen and hydrogen acids indiscriminately, as Narcotina, and, according to Artigosa, Conia, although Liebig gives to it one equivalent of oxygen; while Löwig says it does not contain oxygen, and that it is decomposed by Chlorine, Iodine, and Bromine, when brought in contact with them. Upon any other view we must suppose alkaloids are peculiarly constituted bodies, in which the elements of combination unite in opposition to our generally received laws; that the same elements hold inviolate with regard to every other substance, not excepting the alkaloids of the alcohol series, except when they unite with an oxygen acid of these compounds, as the chloric. If, on the other hand, we consider these vegetable bases to be elementary with regard to the halogen, then the oxygen acids must forego their usual law and unite with an unoxygenised base, which they do not do with others. Perhaps the halogen radicals, in combining with these bases, displace an equivalent of hydrogen, as they are known to do in the alcohol series, and also as shown in the formation of the chloride of carbon, thus acting by substitution. However this may be, I am not inclined to think that the chemical laws are at all interfered with in these combinations, although the rationale is unexplained; and, in our present state of knowledge on this point, it would be preferable to describe them as if they were bases of oxygen acids; and, instead of terming them Chlorides, I shall call them Hydrochlorates, and in the same manner as with other elements.

STRYCHNIA AND CHLORINE — HYDROCHLORATE OF STRYCHNIA. — $\overset{+}{St}$ HCl or (C^{42} H^{22} N^2 O^4) HCl.—This salt is officinal in the Dublin Pharmacopœa for 1850. It is prepared by dissolving Strychnia in Muriatic Acid. It is deposited in fine crystals as the concentrated boiling solution cools. They are four-sided needles, which lose their transparency in the air, and when heated give off Hydrochloric Acid. It contains two equivalents of water, and is more soluble than the sulphate. Its uses will be similar to those of pure Strychnine.

CHLORURETTED CHLORIDE OF STRYCHNIA.—This is formed when a solution of chloride of soda, obtained by precipitating the lime from the commercial chloride of that earth, is added to a solution containing Strychnia. It is a white, insoluble precipitate, and is not crystallizable; it is, however, very poisonous.

Strychnia will most likely form salts with the oxygen acids of chlorine, as the hypochlorous, chlorous, chloric, and perchloric acids.

Chlorine, according to Lowig, converts Strychnia into a base containing chlorine, the atoms of hydrogen being replaced by it. He also says that if this haloid element be added to a soluble salt of the alkaloid it causes a white precipitate. This is most likely a similar compound with that formed by chloride of soda, before mentioned.

Silliman, also, states that both Strychnia and Brucia yield products in which the hydrogen is in part replaced by chlorine.

STRYCHNIA AND IODINE—HYDRIODATE OF STRYCHNIA.—$\overset{+}{St}\ H\ I$ or $(C^{42}\ H^{22}\ N^2\ O^4)\ H\ I$.—This salt is mentioned by Löwig as being insoluble in water; but he does not describe any other Iodine compound but this. Lewuer also states that a soluble salt of this alkaloid is precipitated white by Iodide of Potassium. Brande states that if Strychnia be boiled in Iodine and water that it is dissolved.

The salt is easily formed by precipitation from Sulphate of Strychnia by Iodide of Potassium. It falls down as a white crystalline powder, which consists of needle-like, irregularly-rounded crystals, and differs from most of the others in not being distinctly cubical. It is not soluble, except in a very great quantity of water, and hence must not be washed too freely in preparation. It does not dissolve in Ammonia, nor in Hydrochloric or Citric Acids, but does in Acetic Acid. Sulphuric and Nitric acids do not act very readily on it if they be dilute; but, when concentrated, the salt is decomposed and Iodine given off. It is freely soluble in alcohol. Its uses will most likely be similar to those of the alkaloid itself. The trivial quantity of Iodine which it contains will have little if any influence when united in small quantities with such a powerful base.

IODURETTED HYDRIODATE OF STRYCHNIA.—$\overset{+}{St}\ I, I\ (C^{42}\ H^{22}\ N^2\ O^4)$

I, I.—This compound is the precipitate which falls when the Iodine test is added to a solution of Strychnia. It is not a mere mechanical combination; because, if so, it would not be formed under so many adversé circumstances; and, as the Iodine test is the Ioduretted Iodide of Potassium, I have thought that the alkaloidal combination was similar. The Iodide of Potassium is a colourless salt, and so is the Iodide of Strychnia: for these reasons I have given this precipitate the abovementioned name. It is easily precipitated from solutions rendered very acid by Sulphuric, Nitric or Acetic acids; also from solutions containing most metallic salts, and even from organic mixtures. When well washed and dried, it is of a reddish colour, and when deposited from the alcoholic solution by spontaneous evaporation, it appears like cubical blocks of a yellow colour when examined by the microscope, but it is not very distinct; generally, it is amorphous. The precipitate is light and bulky, comparatively, and is insoluble in water to any great extent; hence its use as a test. It has a slightly bitter taste. When exposed to heat, Iodine fumes are given off, leaving a dark-colored residue; and, if the heat be increased, disagreeable fumes are given off, and a spongy, charred mass is left, even when heated to redness. It is soluble in alcohol. Diluted Sulphuric, Acetic, Citric and Hydrochloric acids, form mixtures of a light yellow colour, but it is not dissolved. The strong acids decompose it, giving off violet fumes of Iodine. Ammonia and Liq. Potassæ abstract the Iodine and leave the Strychnia free as a yellowish powder. The uses will most probably be similar to those of the alkaloid; but, on account of its very great insolubility, its action would not be considered so violent; but this is doubtful. I gave to a kitten about one-third of a grain, wrapt up in a piece of meat. It caused a great flow of saliva; resulting, I suppose, from the taste. In twenty minutes powerful contractions were caused, but they were scarcely so frequent as when the free alkaloid was given. The respirations became very frequent; but the heart's action was not much increased when compared with that of another kitten of about the same age. The pupils were widely dilated—the irides scarcely to be seen. The veins were all engorged with blood, but the lungs not so to a very great extent. The stomach was found filled with air. The poisonous particles were found lying around the cardiac orifice, very few being at any other part. I think half the amount taken would have caused death, because a very large portion was still rolled up in the bolus with which it was given. Death was caused in forty minutes. Its inferiority in point of poisonous effects are, I think, little, if any, inferior to the free alkaloid. The stomachic mucous membrane did not appear to be the least inflamed where the powder was in contact with it. It appeared to act independently of absorption.

Strychnia and Bromine—Hydrobromate of Strychnia.—$\overset{+}{St}$ H B or $(C^{42}H^{22}N^{2}O^{4})$ H B.—I can find no mention made of this salt in the works to which I have access. It can be prepared by precipitating a solution of any salt of Strychnia by the Bromide of Potassium. It is a pretty white salt, which crystallizes in bundles resembling hairs. They are very long and round. It, like the Iodide, is soluble to a slight extent in water; and is so, likewise, in diluted acids. Its uses will, most likely, be similar to those of the alkaloid. Lôwig and Silliman say that both Strychnia and Brucia can be converted into bases in which the hydrogen is replaced by Bromine; being, in this respect, similar to chlorine.

Bromiuretted Hydrobromate of Strychnia.—This is prepared by adding a watery solution of Bromine to a solution of a salt of Strychnia. It is of a yellowish red colour. Its uses will be similar to those of the alkaloid. I gave a kitten $\frac{1}{16}$th of a grain, which caused sickness for a few hours, but no spasms; but, on this amount being repeated, it proved fatal in about twelve or fifteen minutes, with the usual symptoms.

Strychnia and Fluorine.—The Hydrofluorate, although not as yet mentioned by any author, I think could be prepared as most of the homologous compounds are; but I had not the means of examining it.

Strychnia and Cyanogen.—The reactions of Cyanogen, although not an elementary body, approach so closely to those of the haloid group, and bear in reality as much relation to them as Acetic, Citric, Tartaric and other vegetable acids to the mineral oxygen acids,—that I think it can with justice be called the organic halogen radical; because in all its combinations it reacts similarly, being only decomposed by great heat or exposure to the air, under certain conditions.

Hydrocyanate of Strychnia.—$\overset{+}{St}$ HCy or $(C^{42}\ H^{22}\ N^{2}\ O^{4})$ $(H\ C^{2}\ N)$.—This is a beautiful crystalline salt. Kane says the needles are decomposed by a gentle heat. It is prepared, according to him, by dissolving Strychnia in Hydrocyanic acid; but, as the salt is insoluble in five per cent acid, the mixture does not appear to change, and it is difficult to say when the product is obtained. I think that it is very much better to prepare it by precipitation from a solution of Strychnia by Cyanide of Potassium. The temperature of the solution causes a difference in the appearance. If both solutions be cold, it falls as an amorphous or obscurely crystalline precipitate: under the microscope, it appears like very small needles. If, however, the sulphate of Strychnia solution be at the boiling point, the precipitate is amorphous; but, if the temperature be reduced to 180°., then beautiful crystals are formed, rather larger than those of sulphate of Quinine. The crystals are needle-shaped, and when magnified appear four times as large in proportion as when the solutions are cold. When they are obtained by the spontaneous evaporation of the alcoholic solution, they appear like broken fragments of cubes: the different crystalline layers remotely resemble the same appearance which is found in Ferrocyanide of Potassium. They are right-angled and well-formed: some appear tabulated. I also examined a specimen prepared by boiling the freshly precipitated crystals in water. To the eye, it looks like an amorphous powder; but, by the microscope, as well defined four-sided crystals, with straight edges. The solid angles are perfect, except in some places where they were replaced by planes; being parallelopipeds, they will belong to the square prismatic system, two of the axes being equal and the other at right angles. This salt is odourless, and very bulky. It is much less soluble than the pure alkaloid, requiring between seven and eight thousand parts of water for its complete solution, which it renders very bitter. It is much more soluble in boiling water, two drachms of which dissolve nearly $\frac{3}{10}$ths of a grain, and retain it when cold; thus being four or five times as soluble in hot water as the free alkaloid, and not so soluble when the fluid is cold. Its behaviour with alcohol is more remarkable. When this fluid is cold, $\frac{3}{8}$ths of a grain are soluble in two drachms, or $1\frac{1}{2}$ grains in an ounce, whereas only one grain is dissolved in the ounce when boiling; and, if a saturated cold solution be boiled, the excess of the cyanide is precipitated, and this again dissolves as the alcohol cools. When water is added to the cold solution, a certain amount is precipitated. It is soluble in all the diluted mineral acids, and in acetic acid; a small proportion also is dissolved by Hydrocyanic acid. From these solutions it is precipitated as a crystalline powder by alkalies. It is also soluble in the neutral salts, as acetate and sulphate of ammonia and potassa, and apparently also in their free alkalies. Ether dissolves a small amount. It is not soluble in Iodide, or Cyanide of Potassium, or in turpentine, at a boiling heat. Nitrate of silver gives no evidence of cyanogen in any of its solutions; but I afterwards obtained evidence of its presence by adding an excess of caustic potassa to its acetic acid solution, and then the aceto-nitrate of silver, (prepared by adding one-third of the bulk of acetic acid to a solution of the nitrate, containing a drachm of the salt to an ounce of water), by adding an excess of strong nitric acid to the precipitate, the cyanide separated in a white curdy form. I also obtained this evidence by adding the aceto-nitrate to an alcoholic solution, and then an excess of nitric acid. I was unable to find any evidence of the Cyanogen when I used the simple Nitrate of Silver solution, but did so without difficulty with the Aceto Nitrate; and I am sure this preparation contained no Cyanogen, as it was tested previously. I am certain that the precipitate was a Cyanide of Silver, because it was insoluble in cold Nitric Acid, but soluble in it when heated. I also proved this by another method, which I found very convenient for testing the Cyanide: this is, the effect of strong Sulphuric Acid on it; and I think it is fully as distinctive as the Nitric. The former acid dissolves all the precipitates given with Nitrate of Silver, except the Chloride, Iodide, Bromide and Cyanide. The others, as the Oxalate, Phosphate, and Tartrate, are soluble in the cold acid. The Cyanide is dissolved by boiling Sulphuric Acid only, and the other three (Iodide, Chloride and Bromide) are unaffected. The heat which is requisite to dissolve the Cyanide is very easily obtained by leaving a small quantity of water with the precipitate, and then adding the strong Sulphuric Acid when the heat, which is disengaged by the action of the water and acid is sufficient to dissolve the Cyanide completely in a few minutes, if it be not present in too great quantity. In hot Hydrochloric Acid the Chloride is more soluble than the Cyanide. I think from the difficulty experienced in separating the cyanogen from the alkaloid, that it has a greater affinity for it than for the silver. The Cyanide is readily acted on by the Ioduretted solution, and in all its other actions is similar to the free base. Its physiological effects will no doubt be similar to those of the base. I gave a chicken the 1-64th of a grain and it appeared to cause an irregularity in the gait shortly after taking. An hour afterwards I again gave a similar quantity, which caused a stiffening of the legs, but nothing else apparently. In forty-eight hours it had quite recovered. I then gave it 1-16th of a grain; in fifteen minutes it was unable to walk except in a hobbling manner; in twenty-four hours it had again recovered, and I gave it the 1-8th of a grain. In fifteen minutes the spasms came on with difficult respiration, and lasted for a short time; then there would be ten minutes intermission, when they would again appear. It died in about an hour's time, and towards the end there were thirty seconds between each respiration. I had sometime previously put the 1-64th of a grain under the skin, but it caused nothing more than a local inflammation of the part. I put the 1-8th of a grain under the skin on the back of a cat, which caused death in the usual time and with the usual effects. This salt scarcely acts so quickly as the free alkaloid. but just as surely. Its uses will be similar to those of the base.

HYDROFERROCYANATE OF STRYCHNIA.—This salt is easily prepared by precipitation from a soluble salt of Strychnia and Ferrocyanide of Potassium. It is an amorphous white powder, which becomes greenish when in contact with iron and the air; it is inodorous, and insoluble in water; the taste is more metallic than bitter. Its effects and uses will be similar to those of the alkaloid.

Hydrosulphocyanate of Strychnia.—$\overset{+}{St}(HC^2, NS^2)$ or $(C^{42} H^{22} N^2 O^4)(HC^2, NS^2)$. This is mentioned by Kane, but I prepared it before I was aware that he had referred to it. It is easily prepared by precipitation from the Sulphate of Strychnia and Sulphocyanide of Potassium. It is a crystalline powder, which forms radiated four-sided needles. It has been considered to be the best medicolegal test for the alkaloid, as it will detect 1 part in 375 of water. It has a slightly bitterish taste. Its uses will be similar to the base.

Strychnia with the Metals.—These compounds form two classes of salts—those in which the metal acts as an acid, and those forming double salts, the alkaloid and metal being united with an acid or halogen radical. I have not been able to enquire fully into this department, but will describe a few compounds.

1. The Metal acting as an Acid. Strychnia and Antimony. Antimoniate of Strychnia.—$\overset{+}{St}\ SbO^5$ or $(C^{42} H^{22} N^2 O^4)\ SbO^5$. This salt is easily prepared by precipitation from a solution of Sulphate of Strychnia and Antimoniate of Potash. It is amorphous, tasteless, and insoluble in water. This salt, I would suppose, might be of some use as a therapeutical agent if it were enquired into. The Antimonite has not been prepared, and it is difficult to say what compound it would form.

Strychnia and Arsenic. Arsenite of Strychnia.—$\overset{+}{St}\ As\ O^3$ or $(C^{42} H^{22} N^2 O^4)\ As\ O^3$. This salt is easily prepared by double decomposition from Sulphate of Strychnia and Arsenite of Potash. It is amorphous, and requires a large quantity of water for solution; it has no taste, or if any, very slight. What the therapeutical powers of this salt may be has not been yet fully proved by experience. There seems reason for considering it to be a useful Antiperiodic Tonic. The Arsenite of Quinine is much recommended in intermittent fevers, and it is almost insoluble and from analogy we might suppose that its effects would be somewhat similar.

Arseniate of Strychnia.—This is easily prepared by dissolving Strychnia in Arsenic Acid. It is a very soluble salt, I did not crystallize it. This preparation might become useful if its uses were enquired into, and it has the advantage of solubility.

2. Metals acting as a Base in part with Strychnia. Strychnia and Copper, Sulphate of Copper and Strychnia.—$\overset{+}{St}$, or $(C^{42} H^{22} N^{2} O^{4}), SO^{3} + CuO\ SO^{3}$. This salt is mentioned by Pariera as the Cupreous Sulphate of Strychnia. He considers the salt of copper to act as an acid and the alkaloid as a base, but I think it is more easy of explanation if we consider it a double Sulphate of the metal and Strychnia, because the acid unites with each separately, and why not when combined? There are many analogous compounds, as the Tartrate of Potash and Antimony, also called the Antimonio-Tartrate of Potash or Potassio-Tartrate of Antimony. I think the first name expresses the composition in the clearest manner, because there are two combining equivalents of acid and two of bases present. This is proved to be correct by the manufacture of the salt, where the acid Bitartrate of Potash dissolves sufficient Teroxide of Antimony to neutralise it, thus forming a neutral tartrate of each base. This salt is easily prepared by dissolving Strychnia in Sulphate of Copper, when part of the oxide of the metal is thrown down and the alkaloid substituted for it. The solution has a beautiful green colour, and on evaporation yields greenish crystals. These are much more soluble in hot than in cold water; under the microscope they appear to be made up of small tabular crystals piled up on one another. It has a bitter metallic taste, and its uses will most likely be similar to those of the alkaloid.

Strychnia and Platinum. Hydrochlorate of Strychnia and Platina.—$\overset{+}{St}$, or $(C^{42} H^{22} N^{2} O^{4}), HCl + PtCl$. This is a beautiful lemon yellow salt, but differs in appearance owing to the method of preparing. If the Bichloride of Platina be added to a boiling solution of the Hydrochlorate of Strychnia, the salt is crystalline, but if the solution be cold then it is amorphous. When examined by the microscope the crystals appear like cubical blocks lying together. It is insoluble in water and Hydrochloric Acid, but soluble in boiling nitric acid. Its uses will likely be similar to those of the alkaloid, although I think it is rather more active. I gave the 1-4th of a grain to a cat, almost full grown; in eight minutes two or three violent convulsions came on, and in one minute respiration altogether ceased, although the action of the heart continued for some time. On examination I found the brilliant scales of the salt lying on the posterior nares, gullet, and cardiac orifice, thus appearing to act locally.

Strychnia and Mercury. Hydrochlorate of Strychnia and Mercury.—$\overset{+}{St}$, or $(C^{42}H^{22}N^{2}O^{4}), HCl + HgCl$. This salt is formed acording to Pariera, by adding solution of Hydrochlorate of Strychnia to that of Bichloride of Mercury, a white clotty precipitate falls which is insoluble. When cold it has an amorphous form, but if the solutions be hot then the salt appears in a crystalline form. This by the microscope appears like small needles, very similar to some of the other salts of Strychnia. It has a bitter metallic taste, which is very persistent; it is insoluble in water or Acetic Acid, but soluble in Ammonia, Nitric, and Hydrochloric Acids. Sulphuric Acid causes a milky-looking mixture. Its uses will likely be similar to those of the alkaloid. I gave about the 1-16th of a grain to a kitten whose mouth was bleeding. In thirty minutes it became violently convulsed, every muscle was rigid. The spasms came on every twenty seconds during four or five minutes, the breathing was very hurried, but the respirations became weaker, and in twelve minutes the spasms ceased altogether. It now appeared to recover, but in an hour the convulsions again appeared, and it died. I gave a smaller quantity to another, in an hour it became affected with the spasms, but had only two. It recovered so as to take its next meal, but yet appeared to be under the poison's influence, as it screamed frequently but had no spasms.

Hydrocyanate of Strychnia and Mercury.—This is a pretty crystalline salt, obtained by adding Hydrocyanate of Strychnia to the Bicyanide of Mercury. It is very soluble, and by evaporation the salt is obtained in four sided crystals. Its uses will probably not be dissimilar to those of the Hydrocyanate before described.

Strychnia and Iron.—I formed a double salt, the Hydriodate of Strychnia and Iron, by dissolving Strychnia in solution of Iodide of Iron, the alkaloid in part replacing the metallic base, the Oxide of Iron being thrown down. The metal is only present in small quantity. It forms regular four-sided crystals, and is slightly soluble in water. Its medicinal uses will likely not be dissimilar to those of the alkaloid. I gave about the 1-6th of a grain to a kitten; it caused death in the usual time, and with the ordinary symptoms.

All the compound salts of Strychnia are very similar to the alkaloid in action; some are, however, rather more active.

In conclusion, I have to regret that I have not done the justice to the subject which its importance deserves. My desire has been to institute experimental investigations, not hitherto conducted. Several compounds accordingly are treated of which were, to me at least, new. It has been my principal wish that nothing should be described but what I have seen. I have paid most attention to the Iodine test, and I think it could become most useful in proving the presence of the alkaloid in cases of supposed poisoning. I have also alluded so some new methods of preparing this vegetable base. Most of the experiments I have again and again repeated, and feel confidence in their accuracy.