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Observations on Acute Phosphorous Poisoning

by

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Part I

I Introduction
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While attending Professor Madagan's course of Lectures on Medical Jurisprudence, during last Summer Session I was particularly struck with the subject of Phosphorus Poisoning. That an irritant poison should when introduced into the system be productive of the disastrous results which this metalloid is so well known to give rise to - I did not wonder at; seeing. That its action as a chemical agent alone, was sufficient to account for them - but that it should produce the changes in the blood specially as regards its corpuscular elements - and, that in the space of 48 hours it should give rise to changes in such organs as the Liver and Kidney, which would not only seriously interfere with - but, by a metamorphosis of their organic structure even prevent their important functions, did startle me a little. With a view then to making some observations on the subject of Phosphorus poisoning at large - but with special reference to these pathological changes - this Thesis is written.

The subject of Phosphorus poisoning has been little studied - having come before the profession as a Medico-legal subject at least within a very

brief period of time.

In the Continent more than in our own country, have opportunities occured for the examination and investigation - the taking of Phosphorus having become a somewhat favorite mode of committing suicide.

Nor in such cases, has it been used them in actual attempts at murder. Its physical properties in a great measure prevent it being of much service in the hands of a homocide. From it peculiar smell, and taste, its secret administration would be somewhat difficult - but, this accomplished the symptoms it gives rise to, might under many circumstances be mistaken for those of actual disease. From the slow character of the changes that occur before the product are formed which give rise to the virulent phenomena - one important point in all cases of poisoning is lost viz - the sudden appearance of the symptoms within a brief period from the taking of food. Many hours may elapse, and several meals may intervene, before the victim puts at all indisposed - so that the time, and the vehicle, in which it was given - are apt in this way to be overlooked.

The ready access which all parties have to it is another reason why it may be employed with a criminal intent. It is present in every house in the lucifer match heads - and may be purchased from any druggist or ware merchant in the form of the "Vermin Destroyer" which is a most deadly preparation

The fact that its symptoms may be mistaken for those of disease, is not likely to be overlooked by some, who are scientific enough to study the effect of various poisons when they have a homicidal purpose in view.

From these considerations then, but principally from the publicity it has already attained in cases of suicide as a substance of a most subtle and deadly nature - this form of poisoning is likely to become much more common than it is at present -

Observations - few and scanty though they may be - on this subject cannot ~~then~~ be altogether un-interesting - as they include some on a pathology, which in the way of poisons must be considered as unique and one, which as far as the term goes, may be said to present us with morbid lesions which are quite pathognomonic

In considering this part of the subject I shall only refer to those leading physical, and chemical properties which interest us as having a more or less direct bearing on its Medico-legal relations.

The general form in which we obtain Phosphorus is as a "stick" or "roll". Here it exists as a solid, semitransparent substance, of a light yellow colour, changing to white on exposure to light for some time. It has a waxy consistence, and is easily cut with the knife. It is with difficulty pounded and when so treated shows a vitreous shining fracture. It has an odour not unlike that of Onions, but in many cases described most probably from the association in the ordinary recipes met with as Sulphurous. It is exceedingly inflammable and in burning gives off dense white fumes of Phosphoric Acid. It is insoluble in water. (The fact that water in which Phosphorus has been kept for some time) becomes poisonous has been long known, but this seems due not to any actual solution having taken place but merely to minute fragments which have become broken off from the mass - floating in the liquid.)

In Ether and Chloroform however it is soluble - the latter taking up about one fourth of its volume.

In the instance of Ether - the extent of solubility has been I think much over estimated - It is stated that 3T will take up gr viij but from repeated experiments I find that gr ij is the full amount that it can really hold in solution.

With the Ether it forms various compounds - the Phosphorus apparently converting it into various acids.

Pure Ether set aside for a few days in a bottle containing Phosphorus finely divided, becomes sour, and yields of it be decanted and distilled to 1/20 of its bulk in a stream of Carbonic acid - a very acid, thin, syrup which when neutralized with Baryta yields three forms of salts - the first insoluble in water - the second sparingly, and the third readily soluble. The last the Phosphate of Baryta is yellowish white - indistinctly crystalline - turned brown, by the action of hydrated sulphuric acid, and in a state of aqueous solution gives no precipitate with Chloride of calcium - but precipitates. Bichloride of mercury and the nitrates of Lead and Silver.

Alcohol is another solvent of Phosphorus but ~~less~~ more sparingly so than Ether and it can only decompose it in the presence of other substances as the Hydrate of Potash.

Oil is also a solvent but in a much less degree than has been supposed - A solution which is intended to be kept for some time can never hold in perfect solution more than gr $\frac{1}{4}$ to the $\frac{3}{4}$ - when it is to be used immediately as in experiments on animals - at a certain temperature. gr $\frac{1}{2}$ may be taken up.

It is freely dissolved in Bichloride of Sulphur, and Bi-chloride of Carbon, and the evaporation in a current of H. or CO_2 of the solution in either of these liquids - gives the Phosphorus crystallized in Rhombic dodecahedra.

When exposed to the air at all temperatures above 32° (F) its affinity for Oxygen is so great that a slow combination takes place - influenced of course by the elevation of the temperature and the quantity of Oxygen present.

While undergoing this change it gives rise to its peculiar characteristic feature - phosphorescence - In the dark this shows a pale green colour proceeded however according to Graham by the admixture of certain inflammable vapours, and gases, in minute quantity with the atmosphere.

"If air be mixed with either $\frac{1}{450}$ its bulk of Olefiant gas
" - $\frac{1}{1820}$ of Naptha or $\frac{1}{4444}$ of oil of Turpentine - a click of
" Phosphorus appears no longer luminous when exposed to
" its action "

Oxygen must be present in order that this luminosity should occur, but, the purity of the gas does not as one would expect. bear a direct relation to the intensity of the light produced - In pure Oxygen only the temperature rise to 60°, & the gas be rarified, & diluted, it does not appear.

Altho' indicating in a measure the oxidation that is going on, it does not seem to bear a perfectly direct relation to it otherwise we would expect to find it more intense when a large amount of Oxygen was present.

As a result of its combination with Oxygen - three acids may result - dependent on the combining proportion - Hypophosphorous - Phosphorous, and Phosphoric -

These, have each individually, peculiar properties of their own - Of Hypophosphorous little is known - it seems however to be a milder acid in its action than Phosphorous - This latter has distinctly corrosive properties - applied to mucous membranes internal & external to the body it soon by its action completely destroys them - applied to the skin it causes vesication - followed by suppuration, and ulceration. Phosphoric Acid is however milder in its action - on mucous surfaces it acts with considerable energy

but applied to the skin it is unknown.
In the presence of Nascent Hydrogen. Phosphuretted Hydrogen is formed and when placed in contact with alkalies especially at high temperatures this gas also results.
Another remarkable property of Phosphorus is its capability of assuming an allotropic form.
When exposed to a temperature of 240° or 250° (C) it assumes the form of the red variety. The action of light and a certain amount of pressure seem to accelerate the change. It appears as a soft powder, destitute of crystalline structure, varying in colour between scarlet and carmine, sometimes even of a blackish brown tint.
By repeated distillation in an atmosphere of CO_2 it is converted without loss of weight into ordinary Phosphorus - proving that this pure Phosphorus was oxidized. The change occurs at a temperature of 260° (500°F)
It is unalterable in air. Insoluble in Alcohol - Ether, Bisulphide of Carbon, and Terchloride of Phosphorus. Concentrated Sulphuric acid, can only act upon it by the aid of heat, but Nitric acid dissolves it readily.
From its insolubility and its power of non oxidation this form of Phosphorus is perfectly inert as a poison.

- it might act no doubt as a mechanical irritant, but it can never give rise to the same morbid conditions, by which it is usual from the metalloid destroy life.

From its much less inflammable nature, and the fact that it does not fume, it has been strongly recommended for the manufacture of the lucifer match, and although Phosphorus in any of its forms when brought into close contact with the body must always more or less exert a deleterious influence, still, if by the adoption of this form the danger to the lucifer match makers can in any way be diminished - it ought certainly to replace the old form -

Having thus briefly, and in a somewhat disjointed manner considered the leading properties of Phosphorus which bear on our subject - we may now proceed to consider its action on the Economy.

Symptomatology from atology

The Symptomatology of poisoning, is not now considered in a Medico legal point of view, of so much importance as it once was, and it is well seeing that so many conditions may exist, by which the phenomena may be so exaggerated on the one hand, or so masked on the other, that no very definite result can in many instances be come to.
When then the life of a criminal is at stake it is well that we should have other, much more reliable, and decisive evidence, upon which to found an opinion.
In writing upon the vital phenomena which the administration of a poison gives rise to, it is impossible to obtain altogether satisfactory results from experiments on animals. Here we are entirely shut up to the perception of the sensations of the animal by its conduct – in some, sensibility may be preternaturally exalted, and signs of suffering correspondingly intensified, or in others it may be diminished, and an almost perfect apathy to effect be the result – so that conclusions drawn from this source are far from satisfactory.
We are therefore compelled to fall back for information on this subject, on cases which have been recorded and in the instance of Phosphorus

poisoning we can fail at no loss.

Before however finally entering upon the consideration of the symptoms themselves, it will be well to notice some circumstances which cause their modification., and

1st The condition or form in which the poison is taken. Acting in the first instance as an irritant poison - and this dependent on its chemical action - the condition in which it enters the body is a most important consideration

If Phosphorus either in its ordinary form, or better if in a state of solution, be introduced into the stomach - a more or less rapid oxidation occurs, and the phenomena dependent on this, become accordingly more or less speedily developed - if on the contrary, it be taken in the form of the lucifer match heads which have combined with salts of lead, and other substances - the action takes place much more slowly, and the results accordingly correspond - but if, (as has been done) the amorphous form be first employed, either no symptoms arise at all, - or if they do, they are those dependent on the presence of a mechanical irritant.

Dependent then, on the condition must likely to

* The same remarks apply to Phosphorus when beaten in water which is near the boiling point. — for altho' no true solution takes place - still the division of the particles is so minute, that its rapid absorption speedily occurs.

to favour oxidation will be the rapidity with which the symptoms are developed.

II. The vehicle used.

If it be taken in the form of Phosphorous pentoxide, where there is no actual solution, the irritant phenomena will soon become most marked – as being merely mechanically irritant and that, in a very fine state of division the rapid oxidation is favoured – If however, it be well dissolved in oil, ~~& even water~~ so as * to permit of its rapid absorption, the peculiar symptoms denoting its injurious action on the blood will be more likely to result.

Should the fluid have been before administration at a temperature at which oxidation had begun then in all probability, both, irritant, and constitutional symptoms, may appear.

III The relation to Food.

If taken on an empty stomach, the mucous coat unprotected, soon suffers; but, if food be present the pentoxide becomes mixed up with it, and for a time the injurious action is prevented – only however, as being conveyed with the chyme to other parts of the intestinal canal, to become foci for limited patches of inflammatory action in the course of the gut.

II The presence of Fluids will act even more efficaciously as protective agents because, by their means the acids resulting from the oxidation of the Phosphorus will be debilited, and their corrosive action modified. Having then detailed these modifying circumstances, which are not the mere result of theory, but of actual experiment, I shall proceed to consider the various symptoms the poison gives rise to. These are of two distinct kinds - the one, (the Irritant) illustrating a more local action - the other a truly constitutional - and perhaps the best mode of pointing them out, is to give in detail, two well recorded cases, which individually, are illustrations of each - and first the Irritant.

Case I A female set 25 swallowed at intervals of about 12 hours - three quantities of Phosphorus paste obtained from 1000 matches.

On admission into hospital some short time after - the skin was found pale and cool - tongue coated - epigastrium tender on pressure and somewhat hard, belly tympanitic but painless - respirations 40 per minute - fits of dyspnoea coming on at intervals, pulse frequent and almost imperceptible.

Patient complains of constant thirst and vomited frequently - the vomited matters and

When did this case occur & who decided it?

breath smelt strongly of Phosphorus - the former were luminous in the dark - No urine was passed either by the catheter or naturally - Death in 30 hours from the last dose, preceded by cessation of pain, cold clammy sweat, difficult noisy respiration, and hectic delirium.

Case II. " E.B. aet 26, a domestic servant, on March 17th - took ℥iv of Coffee - "added more than three cups of boiling water and "made a strong decoction - Of this ~~this~~ she took one " cup immediately - She then added to the two remaining " cups - other two cups~~ful~~ of water, and thus obtained " still a pretty strong ~~solution~~ infusion of coffee - This she " placed in a pan along with the heads of a number " of lucifer matches and infused them for one hour " and a half - She then reheated the whole almost to " ebullition and swallowed two cups of this infusion " of phosphorized coffee - She then retired to bed " where she rested for nearly an hour, only sensible " of a slight degree of lassitude and headache which " came on immediately.

" Meanwhile the police were informed of what had oc- " - curred and she was sent into Hospital.

" On admission an emetic was at once given - an " hour had only elapsed since she had swallowed " the poison - and she vomited nearly half a pint of

" clear glairy fluid at the bottom of which lay a black
" pulpy matter, and two pieces of half digested meat.
" The vomited matter had a strong alliaceous odour,
" and the blue colouring matter of the matches was
" distinctly visible in them - Later in the evening after
" having taken a draught of water she vomited a glairy
" fluid without any deposit and free of any odour
" of Phosphorus.

March 18th Features unaltered - tongue slightly coated - She complains
" of a metallic taste in her mouth, and a smell of
" the ejus matches which has continued to annoy her
" since the previous evening.
" The vomited matter left in the throat a peculiar
" burning sensation - She said that whilst at the time
" of swallowing the poison nor since had she felt any
" pain in the stomach - She complains only of a little
" heaviness - Bowels had not been moved since evening.
" - Skin moderate temperature, pulse slow (54) respiration
" normal - Mind quite calm.
" She complains of heat and dryness in the nasal fossæ
" - and a painful frontal pain above the eyes -
" She has also had nervous symptoms in the shape of
" formication in the thighs, and cramps in the feet and
" legs. - In addition in the course of the evening she
" had well marked Nocturnal desires.

Where can it be?

" 19th complains of headache and pain in loins.
" 20th - 21st She was so well that she was allowed to
" rise and walk about the ward *
" 22nd The patient was seized with epistaxis and the
" catamenia which should not have appeared for 8 days
" later began to flow in great abundance.
" She became feverish - the skin assumed a yellow colour
" and in the evening after drinking milk she vomited
" and the vomited matter contained a clot of blood.
" 23rd Increased fever - jaundiced appearance - skin
" warm and purpura spots on the chest - She
" complains of pain in the hepatic region and during
" the day she had slight haemaptysis.
" 24th Face sharp - skin dry, hot, and burning - yellow
" tinge deepens and more visible - pulse fair - lips
" very dark - gums bloody - tongue dry and dark coloured -
" Belly tense - hepatic region painful to touch -
" - died during the night

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* Mr Paul the house physician who reports the case, now, thought all danger past but Mr Pidcock who had seen several cases of P. poisoning considered it only an amelioration and that certain symptoms would soon make their appearance, - an opinion which proved correct ~~for~~ ~~on~~ ~~the~~.

In the first case detailed the irritant symptoms are by no means well marked - at least they do not include all the various phenomena which Casper in his "Forensic Medecine" enumerates and which I may quote. "Symptoms he says are immediate " and violent - burning pain in the belly and " stomach - frequent eructations of gas smelling " of garlic - vomiting of matters having the same " smell which as well as the watery stools thine " in the closets - great anxiety and restlessness " - pulse small and scarcely to be felt - cold " perspirations - subsequent peculiar prostration, " sometimes priapism and rapid diarrhœa which " is sometimes peaceful, sometimes attended " with convulsive phenomena"

With reference to the second case it is certainly a most interesting one - and one which I think undoubtedly points to the general constitutional, effect of the poison - The secondary symptoms coming on - when by the inexperienced quite unexpected - show a slow but deadly action going on - an action no doubt, which has its seat in the blood itself. and which by destroying the vital properties, of the most vital of fluids gives rise to a fatal result.

We shall now proceed to consider the symptoms in detail but first with reference to the period of Invasion - Carpenter states this to be immediate and violent" - This statement is however open to question, in fact may be said to be erroneous. Thorne repeatedly watched animals at intervals for some time after administering large doses and hours usually elapsed before the vomiting which was the first evidence took place. The very fact of the dependence of these symptoms upon a chemical change - a change peculiarly slow as we shall see in its occurrence - renders their immediate appearance impossible.

Vomiting. This is usually one of the first symptoms - often preceding the pain. The matter ejected are variously described as having an allaceous, garlic, - phosphorous - or sulphurous odour - the first being the most correct.

Pain may be complained of extending down the oesophagus but this is rare unless vomiting have occured - when, particles of the poison becoming attached to the mucous coat irritation may result - Usually the uneasy sensations are referred to the epigastrium and will be found to be increased on pressure.

It may however extend over the whole abdominal cavity but this is very rare.
Diarrhoea. In the instance of animals this but seldom occurs.- even in cases where on p. m. examination most violent inflammatory action been found to have existed in the intestinal canal. Often such stools are luminous from portions of the metalloid passing out unoxidized.
Hepatic symptoms in acute cases are rare, but the Renal are more common. This is almost to be expected for we know that many substances when introduced into the economy exert a peculiar action on the kidney. Arsenic and Canthanides are the best known examples but in some circumstances Phosphorus seems to have exerted fully as strong an action.
An active congestion with, as we have seen in the case first detailed, complete suppression of urine may take place - more generally however the urinary secretion is much diminished in amount. On examination it will be found to contain albumen - generally to be neutral in reaction - it may be acid - and on using the microscope - blood corpuscles with or without tubular casts will be found present.

The Pulse. This is often very small, and weak - the result of a feebly acting heart - a weakened action dependent either, on impoverished blood or on organic change.

Nervous Symptoms - these are not always present but are by no means uncommon - Delirium - notice, it may be violent, in character accompanied by convulsive phenomena are these usually witnessed. Paralysis, may however go along with, or be entirely independent of these - a paralysis usually limited to one part not unfrequently the arm or other upper extremity being affected.

The Secondary symptoms such as epistaxis and hemorrhage from various other mucous surfaces here no doubt their source in the impoverished condition of the blood and usually appear some days, it may be even longer, after the poison has been taken.

These detailed above, are the most frequent, and they are by no means characteristic even when associated together - Others may be present such as dyspnoea - or irregular cardiac action - the one dependent on the lung becoming affected with an inflammatory action, the other from deep seated effusion into the pericardium.

But an important point in connection with this yet remains for consideration -
From the association of several of these symptoms some especially - the nervous - the hepatic - and the sanguineous (if might so use the term) it has been feared that cases of Phosphorus poisoning might be compounded with that most interesting and most fatal of Hepatic lesions - the Acute yellow Atrophy.
From the history, the symptomatology, and the termination, of such cases a (differential) diagnosis might be very difficult - so that it was well to look at some point which would certainly be the most likely to aid us. ~~in the difficulty~~.
In commencing this we look ~~at~~ first to the history of the case - the peculiarity which has been so often pointed out, and which holds such an important place in the differential diagnosis of poisoning and disease is the sudden occurrence of the symptoms while the patient is in perfect health - In the present instance this may seem to aid us, for. the person seized with acute yellow atrophy will in all probability have been for some weeks previously labouring under a gastro - intestinal catarrh - the symptoms of

which are so well known to the physician as
precursory to an attack of Typhoid Fever.
The situation of the pain complained of will
also aid us - in the one it will be in
the right hypochondria - aggravated by pressing
the fingers under the margin of the ribs - in
the other it will be in the epigastrium and
only influenced by direct pressure.
Vomiting. sooner or later in both cases appears -
in the one the ordinary matters are ejected from the stomach
- only to be quickly followed by violent hæmatemesis
In the instance of an ordinary irritant which
caused by its presence, acute congestion of the
gastric mucous surface, this would not be of
so much importance as rupture of the capillaries
and hæmorrhage might result - but, where
acids give rise to the irritation the case is very
different - the styptic effect which by virtue
of their vital property of astringency they are
known to exert, undoubtedly will act here
and hæmorrhage will accordingly be very rare -
The headache which occurs may be the result
either of the poisoned state of the blood, or the
violence of the vomiting, and is alike present in
both - only the mode in which this means

into delirium and coma, differs in each individually. In the Hepatic lesion we find the patient from an early period, listless - lying in a state of semi-coma - or it may be low muttering delirium.
This gradually deepens - convulsive phenomena may appear and death in the course of a few days, even hours it results.
In the Poisoning case these symptoms are by no means invariably present, and when they do occur come on very rapidly and very shortly precede death.
Jaundice This along with the character of the delirium, is probably the symptoms upon which most reliance can be placed.
In the instance of the Hepatic disease it comes on early, and gradually deepens until the surface of the body becomes of a dark green - in the other, it appears after some time and is comparatively very slightly marked.
The Urine. The microscopic examination of this fluid will also serve to guide us - where the function of the Liver is arrested needle shaped crystals indicating the presence of the Biliary constituent will be visible.
The hemorrhage from mucous surfaces is common to both -

of known the occurrence of such symptoms leave us in any doubt as to the true nature of the case we can bring to our aid Physical Diagnosis. Percussion reveals in the case of disease a rapidly increasing diminution in the Hepatic dullness with a slightly corresponding enlargement in that of the Spleen -

These then are the principal features on which in such cases we can rely as forming a basis, ~~on which~~ for a by no means certain differential diagnosis -

Another important point however yet remains and that is, that in pregnant women more than in any other individual is the Acute Atrophy found to occur - This any fact may serve to complicate the case - All irritant poisons have been at different times, more or less employed, as means of procuring criminal abortion, and Phosphorus has on the Continent already attained this notoriety * ~~and~~ No doubt cases will occur where from its employment, the symptoms will arise, and so an additional difficulty be present in the diagnosis -

* I think this position is open to doubt, for in many animals who have been destroyed by it - the uterus has been found to contain one or more fetuses

Sec IV.

Morbid Anatomy

In this Section I shall only describe the appearances found on dissection - the probable causes of such appearances we shall discuss hereafter.

I. Rigor Mortis

This has at all times but specially in the case of death by poisoning excited considerable interest.

In some such as Strychnia it gives us not unimportant information and altho under ordinary circumstances the time of death, or rather of the p.m. examination - the time of year ~~as~~ the influencing the temperature are all modifying circumstances, still attention is deservedly drawn to it.

In the recorded cases of Phosphorus poisoning* no mention except in one of them has been made of it and in that one instance it was absent -

*which I have examined

The examination was however made only a few hours after death, which arose from a gradual asthenia, about a week after the poison had been taken - so that little importance can here be attached to it.

Bonfly in his experiments on animals* notes that out of six destroyed by means of Phosphorus in four of them was rigor mortis present - in one of these "marked" in another "extreme".

*Lancet June 1857.

Almost invariably Thieme found it "markedly" present
In one case where the animal had small doses
given for a week, and where death occured
eventually from the irritant symptoms coming on
after the last and largest dose - on a summons
evening. when the temperature was good - rigor
mortis was extreme in three hours.
In other instances Thieme saw it equally well
marked, and in nearly as short a space of time
so that it is a point worthy of attention.
The contraction of the muscles of mastication is
specially marked - in several instances so great
has been their tonicity, that their division,
and disarticulation of the jaw had to be
effected, before the interior of the mouth could
be examined -
The expression of the countenance in certain cases
was placid, but this depends greatly on the way
in which the fatal termination occurs.
Petechial hæmorrhages may also be seen over
the surface of the body similar to those
found in Purpura - Scurvy &c.
They are most frequent on the lower extremities
- sides of the abdomen, and back -
Jaundice may also likewise be found when the
Hepatic function has been involved.

I Alimentary Canal

The Mouth is seldom much affected - the poison is generally speedily swallowed and its action on the mucous membrane thus avoided.

In some cases a red line will be distinctly visible round the gum - from this haemorrhage will have occurred during life.

The Pharynx & Oesophagus are usually normal. The lower part of the gullet may be injected - in fact parts throughout its whole length may have suffused - not from the action of the poison while being swallowed so much as, from small particles getting lodged during the act of vomiting and so causing irritation of its lining membrane. A limited ulceration surrounded by an inflammatory line will be the indication of this.

The Stomach - The appearances here depend like the symptoms on the condition and form in which the poison has been taken -

We may have no injection or ulceration present. A contracted corrugated state of the mucous membrane with thick viscid mucous coating its surface may be the only condition observable, but in the great majority of cases the evidences of a local action will be presented.

These may consist of vascular injection of various points on the mucous surface or it may be merely a deep brown colour without any vessels visible. These appearances will be more frequently observed near the pyloric end and on the posterior aspect. The same remarks as to situation apply to the ulcerations. They may be deep penetrating down to the peritoneal surface of the organ or in some cases even through it. Or they may be mere excoriations of the mucous surface and this is the more frequently observed of the two.

Submucous extravasation of blood presenting a small black ecchymotic appearance are also frequently present and if these be removed by a stream of water or a camel hair brush a small excoriation will be at once perceived from the surface of which no doubt the haemorrhage occured. Blood in its peculiarly tarry state when found in the Stomach may also be present but this is exceedingly rare.

A pultic odour may also be perceptible and white phosphorescent fumes have in some cases been described.

The Intestines

The duodenum - If signs of enteritis be present they will certainly be found here - in fact this part of the alimentary canal (the Stomach not excepted) is should say the most likely to evidence the irritant properties of the poison - A deep red vascular injection* attended sometimes by ulceration At points along the course of the small intestine - limited inflammatory patches will be visible and if carefully examined a small portion of the substance more especially if lucifer match heads have been employed will not unfrequently be found adhering at the part and giving rise to the irritation.

The Large Intestine will be found usually normal but at the lower part near the Rectum I have once or twice seen a visible vascular injection while the whole tract of the bowel was otherwise healthy - Haemorrhagic extravasations may also be found here - and feculent masses lodged in the canal may be deeply tinged with blood.

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* The injection is by no means so marked as that observed in cases of Arsenical poisoning.

Briefly in one of this cases we meet with a peculiar "cord like condition" of the intestine - In these instances there seem this and certainly it is peculiar. The gut throughout its whole extent is of excessively small diameter and when grasped by the forceps has really a very hard and cord like feeling - When cut across its cavity is found to be exceedingly small, from an apparent contraction of its muscular coat. The mucous membrane seemed also to be very dry and devoid of secretion.

II Respiratory Apparatus

Trachea. In a case reported by Ogston of Aberdeen* the mucous coat of the Larynx and upper part of the Trachea is noticed as "being of a deep red colour without visible vascular injection" and some importance seems to be attached to the observation. In one of Casper's* cases also "a purplish colour of the Trachea with visible vascular injection" is remarked.

In three animals I have seen it - in two cases injection was present in the one associated with Broncho-pneumonia in the other with Pneumonia alone - in the third instance it was merely purplish and the lungs were noticed as much congested -

The very fact of its extreme rarity renders it a fact of little importance and altho in the instance of other poisons it has been noted in their case too I think its import may be doubted.

Pleura. This serous cavity is not unfrequently the seat of serous effusion - dependent more on the altered state of the blood than on any true inflammatory action in the part -

Effusions of blood are not uncommonly found under its parietal layer

* Medico-Chirur. Review. Oct. 1861.

* Forensic Med.

× Who? & when?

<u>Bronchi</u> may be inflamed - on slitting them up you have visible vascular injection of the mucous membrane with the presence of a good deal of frothy mucus - which in some instances may be tinged with blood.

<u>Lungs</u> In two recorded cases these organs are noted as "congested" and "gorged". No mention is made of any really inflammatory condition being present. In the case of animals it seems different. In 14 out of 16 experiments the state of the lungs ~~are~~ is noted as "congested" "hepatized" or "Pneumonic".

In general one or both were much gorged with blood and presented a markedly <u>red</u> appearance - in others actual hepatization had occurred - the firm carnified looking texture exuding the bloody fluid on section.

At some points apoplectic extravasation had taken place, and this independent of any pneumonic congestion has been noted as being found in the human subject. - only here however as a <u>secondary</u> result.

A Fatty degeneration of the Lung has even been described - In a case recorded by a German physician he ~~records~~ notes the state as follows. ×

" abundant minute fat granules in the parenchyma
" of the Lung principally the lower lobes - partly
" contained in the epithelial cells and partly
" in the interlobular cellular tissue - In the
" latter situation Absorbations of ramified branched
" tubules (blood vessels) were observed which contained
" along with altered blood large numbers of
" fat granules."

III Organs of Circulation

The Pericardium like the pleura frequently contains serous fluid and extravasations of blood are not uncommon on its cardiac aspect.

Heart The organ in the great majority of cases wh. I have examined has presented a contracted generally empty right side and a dilated flabby left. - this dilatation being entirely independent of the presence of blood - as in many cases altho' there was a perfect flaccidity almost no blood was found upon opening the cavity.

Extravasation of blood at the base and apparently under the true cardiac layer of the pericardium has not unfrequently been observed and in one case the coronary vein is noted as hyperaemic. On opening the cavities dark fluid blood will generally be found more frequently on the left than on the right for the reason I have afore-stated - its usually uncontracted condition. White clots have also been found but more frequently when the acids of phosphorus have been employed as the poisonous agent. Ecchymosis has been observed under the endocardium but this seems rare.

The flabby state of the walls of the Left auricle and Ventricle here from careful microscopic examination been found to depend on a fatty change in their muscular texture -
This in some instances is most marked - the whole striae here disappeared and a dense granular mass has taken their place - True oil globules are seldom present, but the condition is very similar in other respects to that found when if we might so term it a natural fatty degeneration has ocurred - It does not seem differ in this that the best marked examples of it are to be found in the layers of muscular fibres immediately underlying the endocardium - The external colour however does not undergo any very marked change and its soft character on pressure is almost the only feature which would lead one to the conclusion that some change in its intimate structure had taken place -
The Arteries and Veins are not affected - their lining membrane as well as their coats seems to remain perfectly natural.

x By whom?

x Do – ?

IV The Excretory apparatus

In the liver and kidney are specially to be found the lendacens or fatty change which seems so characteristic of Phosphorus poisoning. In examining such cases special attention seems always to have been directed to them and consequently this condition which it is of considerable importance to know is always more or less expressly laid down.

Liver - Out of 12 recorded cases[x] the organ in 7 is noted as fatty - in three out of the remaining five death had occured within 12 hours. In 16 experiments on animals[x] I find 12 have this organic change noted and in two out of the four exceptions a very rapid death had taken place.

The occurrence then of this lesion seems well established - The organ is not often much enlarged - it is usually congested throughout its whole extent and at various points on its surface - even in some cases it may be hemorrhagic - a whitish yellow appearance is present -

It is soft at such parts - readily breaks down under pressure and cuts[1] the interior does not show so much the changed colour yet -

What page? p. 406.

Was evident on simple inspection that some change had occured.

On microscopic examination - the hepatic cells were filled with granules and fat cells are visible upon the field in large numbers - but for a more minute and accurate description of such appearances I shall quote the report of a case by Mauthoff -

Year Book of Medicine 1863 +

" In this case the liver was enlarged - and its substance
" made up of two portions - the one red the other
" of a bright yellow tint - which were clearly separated
" from each other - In the yellow part the hepatic
" cells were enlarged and rounded and contained
" numerous fine fatty granules but no globules of fat:
" the connective tissue between the acini was
" increased in thickness and that between the cells
" was much more distinct than in the healthy
" organ - This was still more marked in the
" red portions and the presence of numerous fatty
" granules showed that the tissue was beginning to
" undergo retrograde metamorphosis after it rapid
" growth. These part in fact presented a more
" advanced stage of the affection than the yellow
" In them the fine fat granules had coalesced into
" masses and even into globules of fat - and the

× Evidently Cirrhosis - age of patient not stated - fibrous tissue
increased in this case -

Where?

"walls of the hepatic cells had disappeared.
"This change commenced in the periphery and
" passed gradually towards the centre of the lobule
" - and the marked condition which occurs in
" the later stage of the disease was shown by
" the Lumen being depressed at the red point" ×
This is a minute description of the change which occurs as well as the way in which that change progresses. -
The acini exhibiting fine points in their centre or being made up of fat globules have also by various pathologists been described -

Briefly in the experiments which I have already referred to while taking no notice of the condition of the Lumen itself - notes that in two instances the full Bladder was empty and I was to place no importance on the fact.
In no case have I ever seen it empty - in general it was normally distended - its contents had their normally alkaline reaction and on microscopic examination presented no change.

The Kidneys

These organs will almost always be found congested and in the great majority of cases fatty.

Ecchymosis the occurrence of which seems so often made reference to is specially apt to occur in the renal region either in the cellular tissue behind the organ or under its capsule when this membrane is removed the whitish yellow appearance indicating a fatty change will be observed and the remarkably hyperaemic condition of the vessels noted.

On making a section the pyramids from them the cortical substances will show the congested condition but in the secreting structure will on the contrary usually exhibit but the organic change.

It presents the yellowish tint and is soft and readily broken down under pressure.

On microscopic examination the uriniferous tubules will be found dilated or rather filled with fatty granules and free fat globules will be distinctly visible at some points.

The Malpighian tufts and their capsules seem however in general to be healthy

By whom?

In estimating by experiment on cats and animals the frequency of fatty kidney a fallacy occurs In the cat especially is this lesion under ordinary circumstances by exceedingly apt to be present and to Dr Beale are we indebted for this information -

In three of the recorded cases only is this condition noted whereas in experiments the greater number of which were however performed on cats - 6 out of 9 showed this - in the case of other animals 7 in number only one presented it so that it seems by no means so common as the affection of the liver.

The Urine when present may be neutral or acid - more rare in the case of herbivorous animals hence found it alkaline.

It usually shows on the application of heat a distinct albuminous cloud and on one or two occasions on microscopic examination triple phosphate crystals were found, but little attached to this -

Tubular casts and large quantities of epithelium with blood corpuscles are the more common appearances on such an examination.

V Muscular System.

In the muscular fibre of the heart we have found fatty degeneration to occur in the muscular structures in other parts it is likewise liable to take place.

On ordinary inspection little change can be detected - they may however be somewhat lighter in colour and are certainly softer.

On microscopic examination the striation is found to be almost entirely absent and at some point the sarcolemma seems completely filled with fat granules:

In the left rectus abdominis in a wounded case this was found to have occured and in animals I have detected it several times

The parts in them usually affected are those which are found to be most liable to undergo this change in ordinary circumstances viz the Psoas and Iliacus.

When subcutaneous injection has been practised the muscular tissue immediately underlying the part is not unfrequently its seat.

Volume ?

VI Nervous System

Usually little can be found here - a more or less congested state of the Brain and Cord with sometimes the effusion of serum under the Arachnoid are the appearances noted.

Klebs assistant to Prof. Virchow has, within a very recent period, published a paper* in which he states that a fatty degeneration of the nerve structures is the pathognomonic change in Phosphorous poisoning -

I have examined the nervous tissue in this case of animals but could never detect any change - however the authority of a histologist so great as Virchow* certainly lends to it a very great amount of probability.

* who in his Lectures, I am informed gives support to this Theory. this statement

× By Thorn?

× By Thorn?

The Blood

In cases of poisoning much has been said and written about the condition of this fluid - much that is erroneous, as many seem to attempt to give a fixed colour to ~~that fluid~~ it in all cases where certain particular poisons are employed - In the instance of Phosphorous the colour is by many noted as dark, and some regard this as its almost invariable hue.

In 11 out of 16 experiments and in 5 out of 11 recorded cases, this is the appearance noted, but although occasionally often, it can by no means be regarded as being always so.

It may as there seem it in one or two cases be of a "rich crimson", or, it may separate on withdrawal into two distinct parts, a "red," and black - It seems as if the dark hue were the result of a post mortem change than any actual vital action of the poison - for in the instance where an animal had got small doses of the administered for a week, and was at the end of that time bled (during life) from the Femoral Vein, the blood was noticed to be of a peculiarly rich scarlet hue - a very unusual circumstance as regards venous blood.

Coagulation in Phosphorus poisoning this is markedly absent. The thick consistence which it sometimes has, and noted as empty, or tracky, cannot be mistaken for a true coagulation. It may occur to a slight extent, and in the cavities of the heart as a general rule.

Reaction generally neutral - it may be alkaline - there must be it acid, even when large doses of the acids of Phosphorus were administered.

The Corpuscles By Carpen. and one or two other pathologists attention has been drawn to the state of the corpuscles - Carpen remarks regarding them "blood corpuscles colorless, and "transparent, deprived of coloring matter - "the coloring matter being dissolved in the "uncoagulated plasma"

In the other hand some observers have found no change, but I am certainly inclined to agree with the remark of Carpen.

That the blood undergoes changes, and specially the blood cells in Phosphorus poisoning is easily determined -

After administering one or two grains, to a small animal such as the guinea pig.

x In how many cases was this observed, & how was it distinguished from the same appearance occurring in health?

x Do —

x Do

xx By whom was the dissection made?

- bleeding it before death, or allowing that to occur and then procuring the blood for examination, the change will be at once perceived

No longer are the majority of the cells round;- they become crenate, presenting a remarkably stellate appearance, due apparently to the cell wall yielding at some point from the escape of part of its contents.

The original form of the cell in some cases may be totally lost, a shrivelled up eccentric shaped membrane being all that remains. In the field they no longer, as is the case with healthy corpuscles, form rouleaux, but arrange themselves side by side, forming an appearance not unlike a mosaic pavement.

This colour too is altered - a majority of white cells being present, or rather a number of red in which the colouring matter has been lost - This latter view seems the more probable because these pale cells, are exactly similar in size to those which have retained their original form and colour.

The fact that "the colouring matter is dissolved in the unencapsulated blood plasma" is entirely by microscopic examination difficult to

* Hæmato crystallin is the only one of the proteine compounds which occurs in a crystallized condition. In the blood it occurs mainly as a constituent of the blood cell, and the means which have been suggested for separating it, are such as wire effect the solution of the cell wall and set its Contents free -

Interesting though this substance is, it has not received as much attention as it deserved, in consequence of the difficulty of the methods by which it can be obtained in any quantity, even from the blood of those animals which yield it most readily -

It has long been known that if a drop of blood be placed on a glass slide and be diluted with a drop of water, covered with a covering glass and allowed to remain at rest for some time on a microscopic examination colored crystals (varying in form according to the animal from which the blood is obtained) may be occasionally seen to have formed.

Lehmann showed that if a stream of O and afterwards of CO_2 be passed through the corpuscular portion of blood, mixed with water the same crystalline substance separates in considerable quantities, the experiment having only completely succeeding when the blood of the Rat, the Guinea Pig, or Hamster, is made use of.

(For continuation see back of opposite Page - 461)

determine; but that some such change does take place there[is] little doubt -

This seems strengthened by the fact that if a quantity of the blood be placed in a long narrow test tube and any serum does separate (which is not commonly the case) it has a much deeper colour than that under ordinary circumstances, its colour sometimes amounting to a rich ~~colour~~ crimson.

This can only be due to matter derived from the blood -

Another very important, and as far as I can ascertain unique fact, in cases of poisoning is the occurrence of <u>Haemato crystalline</u> in the blood of animals destroyed by Phosphorus.

That an albuminous crystallization does occur in some of the blood elements has been known for many years - to ~~Virchow and Funke and more recently to~~ Funke and Lehmann are we indebted for researches, and the information we possess on this subject. *

~~Günsburg was one of the earliest to observe this and he curiously enough first saw the crystals in the substance of a thymus gland which had undergone fatty degeneration.~~

Kühne* in Nov. 1863 showed that the process which Virchow had stated the bile acids possess, of dissolving Haemato crystalline, must be taken advantage of in separating this substance from the blood and he has published an excellent method of obtaining the crystalline albuminous substance, and which consists essentially in treating blood clot, separated as much as possible from serum, with a concentrated solution of Glycocholate of Soda.
Under no circumstances hitherto, however as far as I am aware, has the blood been noticed to become spontaneously full of crystals of Haemato crystalline.
In addition to the pathological and Semeiological value which I hope to be able to show Haemato-crystalline possesses in relation to Phosphorus poisoning - the observation which I have made, and am about to allude to, are of importance indicating as they do a new and very easy method, of obtaining large quantities of Haemato crystalline.

* Neue Methode zur Darstellung des Hämatokrystallins von W. Kühne.
Sep. abdr. aus dem Centralblatt f. d. med Wissensch. 1863. No 53.

addition of water to blood on a microscopic slide, one molecule a cross was immediately placed and the crystallization allowed to go on - or he obtained them from old haemorrhagic effusions in cerebral or pulmonary apoplexy - or from the ruptured Graafian vesicle in the Ovary.

No one he remarks has been able to obtain them in such amount as to permit of their chemical examination, and this remark made many years ago seemed still to hold true.

The reactions he found them give were briefly as follows.

Liq. Potassae caused the colour to become more intense - the colouring matter to become diffuse and then to be dissolved.

Strong Mineral acids destroy them and leave a granular mass

Acetic acid has no influence - neither has Ether or Alcohol.

Reichert who in 1849 published a paper on the subject - and who discovered them as tetrahedral crystals on the placenta of a newly matured foetal Guinea pig, gives the result of his chemical examination

Acetic acid caused expansion and lightening of the colour.

Hydrochloric Acid - Crystals do not expand - become of a light yellow, or brownish hue, but are otherwise unaltered //
Sulphuric and Phosphoric acids acted in a similar manner.
These then are the leading characters which this form of albuminoid crystallization presented.
Their behaviour on the addition of Ether - remaining unchanged, - does away with the idea which Zuncy or other author on this subject had stated - that they were of a fatty constitution.
That fatty acids however crystallize out with them is rendered probable by the observations of Dr Parkes. Medical Times and Gazette 1852
In his cases they were obtained from putrid blood and on the addition of water -
In all the modes of obtaining them artificial means such as these have been resorted to - and never as far as I can find have they been observed in ordinary circumstances. ~~except in old hemorrhagic extravasations~~

I considered it then an observation of some interest and importance, while examining some 8 or 10 days after death, the blood of a cat which had been poisoned by Phosphorus to find large quadrilateral & hexagonal columns of a deep ruby colour and evidently from their outline

4 How many?

of a crystalline formation floating about among the remaining blood cells.

This led me more closely to examine the condition of the blood in such cases and with the following results

In the great majority of instances some days elapse before the crystals appear - in some however they were found on p.m. examination.

They seem to undergo a regular development but this is very difficult to follow - If you remove a small quantity of blood, either at the time of the p.m. examination, or better two to four days after, place it on a microscopic slide and over it a large square cover so as to cause a diffusion of the fluid over a pretty large surface you may see floating about among the altered blood cells small needle shaped crystals. There is however a point of some importance here. - in cases where animals have been destroyed by the acids of phosphorus or even where death had resulted from some other cause small square crystals resembling those in Fig II Plate I may be observed - They are from their colorless, refractile, glistening appearance - and the way in which they roll or turn upon themselves

evidently Phosphatic.

The true haematoid crystals are larger, more really needle shaped. They may hence attached to their cells one or more blood cells & be floating perfectly free. They are of a very light yellow colour and do not transmit or reflect light. A day or two is allowed to elapse and again the blood is examined. The crystals are now much longer and they are beginning to assume a more markedly red colour. They may now be seen to cross each other on the field as in Fig 5.

Gradually these seem to get less longitudinally and increase laterally but this is difficult to determine as placed on a slide. Removed from the matrix before they cease to undergo any change of a progressive? kind (at any rate.) They now become of a uniform square shape ▭ - some are long and narrow, others short and broad, and they hence assumed a rich ruby hue. They may now be said to have attained their maximum of development. If such may be said in such circumstances to exist.

This will, in those cases where they appear just about the 4th or 6th day, usually be attained

Ren Yels occurs spontaneously in many animals

about the 12th or 14th day.
Their appearance in such blood occasionally would be a matter of interest, but when it becomes (in the case of certain animals at least) almost invariable then it may surely be regarded as important.
The conditions which give rise to them, or rather favour their formation, are not easily determined — one thing is almost certain, that they have a direct relation to the amount of the poison administered and hence naturally to the size of the animal.
In the cat, guinea pig, and squirrel, where a comparatively large dose has been given, (gr T to [illegible]) or even better where repeated small doses have been administered, they appear very speedily — In the dog I have seen them often enough to confirm me in the idea that they were intimately associated with the action of the poison; but by no means is the rule of their appearing here so certain as in the others.
In all the artificial methods which have been adopted for obtaining them the great object to be attained was the rupture of the cell wall — the escape of its contents and their subsequent crystallization.

It is thus the best proof we could have of an actual alteration in the blood cells in acute Phosphorus poisoning allowing of the escape of the contents and their subsequent crystallization; - for without any means being employed, the blood being simply set aside in a test tube, crystals soon or later make their appearance. The greater or less density and strength of the cell wall in different animals accordingly materially affect this occurring, and no doubt the resistance of the dog which Thomas first referred to is an example.

In man of course Thomas not had an opportunity of examining the blood but from Carpenter's description of the "colouring matter being dissolved in the uncoagulated plasma" it is exceedingly probable that this too it may occur.

The diffusion of the poison in the circulation of a large animal must also influence the crystallization taking place - but, when the corpuscles have been subjected to such an amount of action as to cause the serum to be of a dark red colour from the dissolved haematoglobin, there is little doubt but that coarse or later a more or less distinct crystallization will be present.

From the different periods after death at which these crystals are to be found. it seems probable that agencies are at work externum to the body, which favour or prevent their development - what these are is very difficult to determine and perhaps the best way of illustrating this, is to detail the notes of some observations on this subject.

A large dog was destroyed by ½ oz of Phosphorus in an oily solution, being injected into the stomach - the oesophagus immediately tied and death ensued in 48 hours.

Three portions of blood were obtained from it.

A. drawn before the poison was administered.

B. taken from the right side of heart at p.m.

C. removed from the Vena cava 48 hours after.

Monday Jany 30th four days after death.

A. is firmly coagulated but neither B. or C. are.

On microscopic examination no change could be detected in the blood corpuscles of A. in B. this was marked but no crystals were present in C not only were the corpuscles irregular but beautiful crystals were apparent.

Jany 31st. Neither A, nor B. present any trace of crystallization; in C. this is most distinct.

At this I was somewhat surprised and began to consider what influences had been at work to cause their so rapid appearance in Blood C.
Cold was the first which occurred to me seeing that the temperature at the time was very low and that blood left in the Vena Cava after the removal of the abdominal viscera was very freely exposed to its action.
I accordingly took some of the blood B, in which the corpuscles cells showed me the condition was present which seems to be the primary cause of the crystallization appearing and I exposed it to a freezing mixture at 32°(F) for 10 minutes.
At the end of that time no coagulation had occurred, there was no change in its colour, and no crystals were visible.
It was now allowed to remain 48 hours in a similar mixture, and at the same temperature.
At the end of that time there was no further coagulation - the colour seemed darker but no crystals were present.
The blood was labelled and set aside and subsequent observations showed that the crystallization took place no sooner in it than it did in the blood, unacted on by × see back of this page for continuation of sentence.

any artificial external agency. persons I think that cold can hardly be looked upon as a favouring cause.

through another quantity of the same blood B. and at the same time the other experiment was going on I passed oxygen for about 5 minutes.
At the end of that time the corpuscles seemed more scarlet in colour but no crystals were visible.
Next day (Feby 1st) however they had appeared and so rapid was their formation that they had attained their full development before those in the same blood which was unacted on, or that portion exposed to the freezing mixture had shown them at all.
Whether this was due to the mere passage of the gas acting mechanically it is difficult to determine but I am rather inclined to believe that the gas in some way or other may be regarded as a favouring cause.
Feby 2nd: In C. the blood crystals are perfect.
– 2nd. Crystals are discernible in all the different specimens of blood with the exception of A. in which no change whatever has occurred.
(This ~~then~~ was 8 days after death)
The crystals in B are very small, and in C which showed them so beautifully and at such an early period, ~~its~~ their consistence is becoming

to draw (track) that it can be impossible to demonstrate their existence.

What then was the cause of the blood which remained exposed in the Vena Cava exhibiting them so soon? Altho' perhaps materially aided by exposure to the air and then to the influence of Oxygen, the concentration* which took place from its being exposed over a pretty large surface was perhaps the main cause.

When you allow the blood to remain in the vessels of an animal for some time after death you are much more likely to have the crystals appear early, than when the blood is drawn while the body is yet warm.

Perhaps the relation of the fluid to the vessels in which it circulates act as promoting it.

Water, or water and a little Spirit, undoubtedly quickens their formation, but that under ordinary circumstances the water alone does not prove is to them is readily demonstrated by adding a like quantity to ~~the~~ a similar amount of blood drawn before the process is administered, when the one will be found to yield beautiful crystals whilst the other remains unaltered.

* This is perhaps rendered more probable by the fact that if you shut up the blood in a close tube the development ceases.

that it is not the result of a mere putrefactive change I have also determined by obtaining blood from the animal before the experiment was begun - exposing it to exactly similar conditions and for the same length of time as that obtained on a p.m. (and to which nothing had been added) - At the end no crystals were found in the one but abundance in the other.

That here a small quantity of water should favour ~~the~~ crystallization is rather a curious fact. It may no doubt assist mechanically in discharging by rupturing the remaining blood cells (which altho' not sufficiently acted on by the poison to allow their contents to escape must undoubtedly have suffered alteration to some extent) or it may allow of the crystallization taking place more readily by its mere presence - for I am rather inclined to believe that the coloring matter itself independent of the globulin has a power of becoming crystalline.

When water has not been added the most favourable circumstances for its occurrence, are when a small quantity of blood is placed in a flat dish and freely exposed to the air, taking care that too great concentration ~~does~~ not occur.

whenever this latter place, when the mass becomes treacly, the crystallization, either from the pressure of the corpuscles yet remaining or of the crystals themselves against one another, speedily disappears; and, no matter how distinct and beautiful they may have been before, in 24 hours under such circumstances they will have totally disappeared.
The chemical properties of these crystals seem however to be by no means so well marked as those obtained by Virchow, Reichardt &c.
All acids acetic included dissolve them and leave only a reddish granular mass
Spirit and Ether unless much diluted have a similar effect - even Glycerine gives rise to the same change.
At the temperature of the body they slowly disappear - Place some blood on a slide which you know from previous examination to contain them - retain it in the palm of the hand for some minutes and they will be found to have disappeared -
Under such circumstances it is impossible to obtain them by concentrating a fluid in which we suspect them to exist.

From the blood of a cat which had poisoned with Phosphorus Dr. Gampe separated Haemato-crystalline by the method described
Its solution in water was not precipitated by either Basic acetate of Lead or solution of Corrosive Sublimate - the peculiar hemsing being only produced.
A solution of ~~acid~~ Subnitrate of Mercury and heat of about 150° (F) sufficed to effect complete coagulation.

* independent of the action of heat itself.

the very coagulation of the albumen* which from the invariable presence of blood corpuscles in such fluids is sure to ensue on the application of heat. causes an effectual barrier to their appearing.

Owing to these properties it is almost impossible to preserve them as microscopic preparations - the only way in which it can be done at all is to mount them dry.-

After a time they tend to run together, break down, and form a granular mass. the only indication of their former existence in it being - that it presents more or less of the ruby colour.-

In order to obtain them for chemical examination for which they are readily got in sufficient amount the best plan is to add to 100 parts of the blood 20 of Alcohol of 90 p.c. when the crystals will be precipitated - they may then be collected washed with Alcohol of a similar strength to that used in the first instance, and afterwards by iced water - Distilled water when added will now dissolve the crystals and a beautiful red coloured solution be obtained to which chemical

reagents may be applied.
Unfortunately I was unable to follow this out but there is little doubt that interesting and important results might be attained - results which would be unique as no opportunity as far as I know, has ever previously been presented for obtaining them [in sufficient amount].
From the peculiar manner of the occurrence of this crystallization, from the chemical and physical properties which the crystals possessed, (altho' from the circumstances it occurred in it could not well be anything else), still a certain amount of doubt remained as to their being really Haemato crystalline.
No chemical tests as proving this, were known so that we had recourse to other tests which may be termed truly vital. Knowing from the result of Funke's investigations that some animals presented different forms of Haemato crystalline crystals these animals were made the subject of experiment.
To a guinea pig I gave gr. ij of Phosphorus It died within 12 hours. On a p.m. the

These Xals are commonly found in the normal blood of the Guinea Pig —

change in the blood cells was next marked but no crystals were visible - In the course of 48 hours however distinct tetra-hedral pyramidal crystals were present. To a squirrel a dose of Phosphorus paste was administered - it likewise died within the 12 hours - A p. m. was not made for 24 hours when changed cells alone were visible - In the course of the 24 hours however hexagonal crystals appeared.
These two experiments then were quite sufficient to prove, taken in connection with all the other facts - that the crystalline bodies were hæmato crystalline.
By this process then any amount may be procured (both the blood of the cat for such experiment would especially pure) and the chemical and physical properties readily be determined.
What I next will be investigated by some one much more able for such a task than I am -
with reference to its relation to the acids of Phosphorus shall refer to this under the head of the changes which the metallic

probably undergoes in the blood - meanwhile I may only state that in animals destroyed by Phosphorus compounds never have I seen except in the case of the Guinea pig these crystalline bodies appear.
In that one instance water also was added - and which afterwards, I found was quite sufficient independent of any other agency to give rise to it, so that it may be considered as of little or no importance.
Phosphuretted Hydrogen does however seem to give rise to this production, but whether or not the Oxygen may by its mechanical action is difficult to determine.
Having now considered the pathology of the blood perhaps too fully, a word or two on Treatment and then we shall pass to the consideration of the Theory of Phosphorus poisoning.

Section V
Treatment.

this has always been laid down and must in appearance be founded on theory, aided to a very considerable extent by the symptoms we observe during life, and the morbid phenomena indicating the lesions which are most apt to occur and which it becomes our special duty to combat. Emetics and the Stomach pump in the first instance are I think clearly indicated at least before the irritant phenomena set in. Here an indication that ulceration was commencing, or was in progress, would of course clearly contra-indicate the use of the latter means, but where this is not present from the very fact that the poison like Arsenic is so apt to become attached to the Gastric mucous walls - it must be looked upon as the best way of getting rid of it. As to purgatives, Castor oil would be inadmissable knowing as we do the solubility of Phosphorous in oily substances - Better give Epsom salts which would not only act as a purgative but as an antidote (to a slight extent at least) to the acids which are formed - or some of the Vegetable Cathartics so as to ~~cause~~ produce

a speedy purgation, and in this way get rid of particles remaining unacidified
Where the virulent symptoms have set in Magnesia or Lime may be employed as antidotes and Opium freely administered to allay the inflammatory action.
In the more Chronic form where the patient is labouring under the effects of the blood poisoning, Iron Stimulants might be administered with advantage. We are all familiar with its curative power in cases where the red corpuscles have from any cause become diminished, and with its power of acting as a capillary styptic, and certainly in the present case both these are to be fulfilled. The functions of the bowels and kidneys may also be promoted, but this is difficult to effect as both organs have a tendency to become congested and this is always a contraindication to stimulation of function.
Magnesia or Lime may also be given so as to combine with the acids which will come or later, in the blood, and so form salts which may on the one hand be assimilated by the economy, or eliminated by its depurants.

Stimulants would also be necessary, to support the system under the adynamia which is almost certain to arise

On point I may remark here, and although "my theoretical, it has so much of practicability about it that I think it worthy of notice

In the case of a cat which I wished to destroy numerous doses of the poison were administered as much as gr ¾ up to gr iij daily for several days in succession without any bad result - the stomach tube was used the poison in an oily solution being injected through it - but in order to facilitate the process and to carry it on with less personal risk Chloroform was regularly administered - This did not strike us for some time as the probable cause of the inertia of the poison but as soon as ~~it~~ inhalation was left off death occured in some 18 hours after the last dose -

In the presence of Ether, Phosphorus does not undergo oxidation may Chloroform not have a similar effect and may the blood which day after day was impregnated with it - owe not have had the oxidative change

prevented, and the fatal result delayed?
That it became ultimately changed was amply proven, as it not only presented the most markedly changed corpuscles, but the most beautiful crystals I ever saw.
This may have been the result of the large quantity of the nut-alloid in the blood the moment the conditions were removed which prevented it undergoing a rapid oxidation.
It might then be worthy of trial, in such a desperate case as that which we have found Phosphorus poisoning to present.
Moreover it acts as a stimulant to support the failing vital powers and, as Dr Simpson has pointed out is of much service in the treatment of abdominal inflammations — conditions which may ~~tie~~ all be present in one individual case.

Part II

The Theory of Phosphorus Poisoning.

In considering this part of the subject I shall do it under two heads.

1st The changes the metalloid probably undergoes. in (a) the Stomach. (b) the Intestine.

IInd The changes it probably undergoes in the blood-
ain

1st As to the changes it undergoes in the Stomach.

The symptoms and the morbid phenomena as these already pointed out bear a most important and most decided relation to the mode in which the Phosphorus is taken.

It cannot well as Phosphorus pass through the tissues unoxidized, and this is readily proved by placing pieces of it which have been previously carefully weighed in the subcutaneous cellular tissue of a living animal and allowing ~~it~~ them to remain for ~~some~~ days.

At the end of that time ~~it~~ they will have lost nothing in weight, a fact almost conclusive in itself but rendered more so when associated with the state as regards chemical reaction in which we find the surrounding cellular tissue. It remains as it normally is alkaline - had any oxidation taken place the acid state as well as the loss of weight would readily be detected

So far then this experiment holds good as confirming

a grand general fact viz that Phosphorus en masse cannot so pass. When in a minute state of division held in solution by readily absorbed fluids its passage through the absorbents and thus its entry into the system is readily enough accomplished. Dependent then in a most material way on the condition it enters the Stomach will be the changes it undergoes there.

Suppose it is introduced in such a form that it remains for some time. it undergoes oxidation. How is this accomplished? Two theories for its explanation have been advanced. 1st That it is dependent on the free Oxygen which we know is at all times more or less present in the ~~organ~~ Stomach and II that it depends on free Oxygen obtained from the disintegrating ~~tissues~~.

The latter certainly seems most improbable and it will be well before proceeding further to consider the objections to it. Two simple experiments easily performed certainly furnish us with the test. Add to yolk of egg or any other animal substance Phosphorus either in substance or solution. place it in the receiver of an air pump or in any other situation where the free access of atmospheric air is prevented and allow it to remain for some time.

On testing it the reaction will still be neutral
– no acidity can be detected.

II Inject under the skin of any animal an oily solution of Phosphorus (taking care that you do not inflate the cellular tissue with air.) allow it to remain until complete absorption has taken place and the normally alkaline reaction of the tissues will be found unchanged.

These are sufficient I think to show that the disintegration theory is incorrect, in fact were it the cause it would be difficult to find how the process is begun, as it is only when an actual disintegration is occurring, (that having by some means of Oxygen been commenced) that the gas could be evolved.

The gas Oxygen then we may look upon as the cause of the Chemical action – It must necessarily be a slow one, as the amount of the gas supplied is very limited, and even under the most advantageous circumstances exposed to a free current of air for 48 minutes 15 days for it complete acidification showing how slowly the change takes place.

Some of it undoubtedly remains unacted on and as it entered passes from the system – the remainder however and by far the larger portion becomes

under the action of the oxygen for which it manifests such a peculiar affinity resolved into its ~~two~~ ~~main~~ acids. Hypophosphorous, and Phosphorous with perhaps a little Phosphoric.
All are when brought in contact with such fine structures as the gastric mucous membrane sufficiently powerful to give rise to its more or less complete destruction. The Phosphorous acid is no doubt the more active and to its power probably may be due those perforations which are found - not extending merely through the mucous coat but reaching and even perforating the peritoneal itself -
All may give rise as I have proved by experiment to those mere erosions of the membrane which are so commonly present and all I need hardly say are quite capable in such situations of producing an inflammatory action.
So far then, we have followed their action but like all the gastric contents they sooner or later pass into the bowel - let us see what changes occur there.
In the upper part of the duodenum little change takes place and this may account for the inflammatory action which we sometimes find being limited to this part.

For we know that in the Hepatic, Pancreatic and Intestinal secretions alkaline carbonates exist and as soon as the acids of Phosphorus come in contact with the alkaline salts so placed in them very a natural decomposition takes place, Hypo-phosphites. Phosphites and Phosphates being the result. Thus their corrosive action is prevented and thus I believe accounts for the great rarity of signs and symptoms of enteritis in such cases.

A limited inflammatory action in the case of the intestinal canal is in all probability due to a part of the Phosphorus which has passed down while undergoing oxidation and lodged at the affected part.

But another and a by no means improbable change may occur. Phosphuretted Hydrogen may be formed. Alkaline Hypophosphites, and Phosphites when brought into contact with nascent Hydrogen hence by actual experiment been found to give this gas as a result

Hydrogen in its nascent form is very readily found in the intestinal canal and though small in quantity when undoubtedly combine with the Phosphorus so presented to it and form Phosphuretted Hydrogen.

*

Dello Avvelenamento prodotto dal Fosforo
per il Dott. Ranieri Ballini
Firenze 1864.

this gas is intensely poisonous and once it has been supposed generated in large amount a much more speedy and a different form of death would result

* Bellini a Florentine experimentalist who has made some most interesting observations with reference to the subject of Phosphorus poisoning has directed special attention to this point and altho' he has carefully collected the intestinal gases in two cases where repeated doses of the best alkoid had caused death yet he was unable to detect the presence of the gas.

It may however as these stated not improbably result and though small in amount is so powerful in its action that it may have not an unimportant part in the causes leading to a fatal ~~issue~~ result.

As a result in cases of Phosphorus poisoning we may expect to find in the intestinal canal Phosphorus unchanged, alkaline Hypophosphites, Phosphites, Phosphates, and sometimes if not always PH_3.

Then are all substances capable of absorption and must necessarily sooner or later enter the blood, let us then in the next place look to the probable changes which do occur.

II Changes which probably occur in the Blood.

From the experiments of Dr. Owen Rees it has been satisfactorily proved that one of the great ends of the respiratory process was by a kind of oxidation to convert the fatty matters derived from the alimentary canal and which were charged with Phosphorous into the condition of Phosphates, a condition in which they were readily assimilated by the tissues.

A priori reasoning then, when Phosphorus is introduced into the system though in much larger amount, a similar but a correspondingly slower change must occur. The Phosphorus becomes oxidized but so much slower is the change from the quantity of the poison in the circulating fluid that the minor acids ~~would~~ may to a considerable extent in the first instance at least result.* This oxidation has been proved to occur by various experiments. Magendie injected into the jugular vein of a dog an oily solution of Phosphorus – immediately white luminous vapours were given off from the lungs indicating most unequivocally the change which was taking place.

* but I doubt if a free oxidation does not take place at once.

Bellini likewise has made experiments not so much with a view to determine as

Magendie did the actual changes in the lung by noticing the vital phenomena which resulted — but by carefully testing the reaction of certain of the fluids, in cases where death had resulted from its administration, to determine whether by evidencing a change in these, they showed prime that acids as being the necessary result of the oxidation were actually formed. The following are examples of these experiments and prove I think satisfactorily that this change does occur.

He took two rabbits of the same age and which had been subjected to the same regimen. To one he gave a dose of extremely divided Phosphorus and then allowed them to feed. In 16 hours he bled them from the external jugular and collected the blood in two little beakers + As soon as the serum had separated he tested its reaction with litmus and turmeric papers and he found that the serum of the blood of the poisoned animal was neutral while that of the healthy animal was alkaline.

He repeated the experiment administered to one of the animals phosphorized oil in small and frequently repeated doses so as to induce diuretic slowly and when it was about to die 32 hours from the first administration of the poison, he drew blood from the jugular veins of both. and on testing the serum which separated from the blood he had drawn he found that of the healthy animal alkaline while that of the poisoned was faintly acid.

The alkaline reaction of the peritoneal fluid in such cases he also found had become either neutral. or acid.

In my own experiments I have more than the blood really acid as a general rule neutral, it may be alkaline. That this happens depends on the amount of the poison taken and the quantity of acid resulting is very probable from the fact that in those cases where large doses of Phosphorus or Phosphoric Acid were employed the fluids were rendered much more distinctly acid (or tending to it) in reaction.

Blondlot however seems to doubt this cleavage, his grounds being apparently based on the fact that in the urine of a person taking only solution of Phosphorus in medicinal doses he could not detect Hypophosphites or Phosphites.

but that he could detect them in the urine of a person who was taking 15 centigrammes (2.5 gr) of Hypophosphite of Soda. Neither of these reasons are however of any great value, for the very fact of a man taking Phosphorus in medicinal doses, is quite sufficient to enable us to know that the quantity must have been very small, so small indeed that diluted in the mass of the blood, passed through the lung its almost immediate conversion into Phosphoric Acid would result and instead of being eliminated it would very probably be assimilated by the system. On the other hand when a considerable quantity of a salt such as the Hypophosphite of Soda was taken, its elimination would not only be more rapid but would in all likelihood occur (to some extent at least) in the very form in which it was taken.

When Phosphorus passes into the blood it is probable that to some extent all its acids result, but more likely I should imagine is, in many instances a full oxidation likely to occur and Phosphoric Acid to be at once formed. This, circulating in the mass of the blood will combine with its salts, and perhaps partly due to this, as well as to the changes which the Phosphorus itself gives rise

to in undergoing the oxidation, are the changes in the corpuscles which we have found to occur. Part seems however to remain unchanged, to be conveyed to various parts as the Liver and Muscles in which it becomes lodged, and where by chemical analysis it is readily detected.

Two ideas, or theories, seem to have for their foundation the knowledge of the liability of Phosphorus to undergo oxidation - viz. in the one that the previous changes produced by it as a poison were due to its becoming Phosphorous acid, the other, that a more full oxidation took place and that Phosphoric acid was the cause of the fatal result.-

The conclusion, was a very natural one, and one that was almost certain to have been arrived at. but in order to test if possible its true bearing I performed two series of experiments - one with the Phosphorous, the other with the Phosphoric acid, and first as to the former.

In two cases the acid was administered by the Stomach. Those deaths soon resulted and the virulent phenomena, more especially the ulceration were found most marked. No other organs but those of digestion were affected in the one case, in the other the Liver and Kidneys were partly

and the blood cells in one or two instances were irregular. In the other experiments, subcutaneous injection was practised in order to avoid, deaths occurring from the intestinal lesions which prove so quickly fatal, and to allow at the same time the acid more directly to enter the blood. In one case ten centigrammes of the strong acid were used — in the other five.
Both animals lived a week, dying eventually not from any true blood poisoning but from the local corrosive action of the acid.
So strongly marked was this, that in the one case the whole skin, cellular tissue and muscular structures over the whole area of the injection sloughed, the ribs were superficially eroded and the pleural cavity opened into.
In the other more superficial sloughing took place but the suppuration which occurred in both, in the cellular tissue in the neighbourhood was so great that a death by Asthenia took place.
In neither case on a p. m. examination was there found any lesion in any organ except those dependent on the destructive local action — no fatty degeneration and no blood change could be detected.

As a result of these observations I came to the conclusion that either Phosphorous acid may be formed in the oxidation process, and this I would not regard as very probable, it has little or nothing to do with the fatal issue.

Its properties are those of an <u>acid</u> not of any- -thing so specific (if I might use the term) as Phosphorous seems to be.

It is not a true <u>vesicant</u> as has been supposed Nor is a true <u>corrosive</u>. The action which it exhibited in the case of the animals obtained was sufficient to evidence this. but if possible to prove it more effectually, I had recourse to personal experiment: A friend and myself applied to the dorsum of the hand a small quantity of the same acid which I had employed in the experiments.

A minute after the application a sense of smarting with a slight burning sensation was perceptible In four minutes desiccation had commenced in the tissues complete. The pain now ceased and for twelve hours was not again experienced, At the end of this time however it became intense, the inflammatory action in the surrounding parts was very great and constantly sloughing to a considerable depth of the whole

Die Acute Phosphor-Vergiftung.

* von Dr. Ph. Munk aus Wr. z. Leyden

Berlin 1865.

area over which the acid were applied ensued.
In my own instance a most unhealthy form of ulceration supervened which ultimately healed under the use of the Iodic lotion.
The pain and irritation it gave rise to were however during the whole period of its continuance very great. So that its use as a counter irritant could I think in many cases be attended with beneficial results.
Seeing then the purely local action of this agent we cannot say and it is likely to produce the various changes which we have found to characterize Phosphorus poisoning.
As to the second or Phosphoric acid theory, this is more recent in its origin.
It has been put out by two German authors.* and by them is considered as the cause of all the various pathological phenomena, which have been described.
The most decided objection to this theory consists in the fact that in the very great majority of cases where not only the blood changes, but even the fatty degeneration were present a very small amount of the poison had been taken and consequently a very small quantity of the acid

~~resulted~~ could result. Suppose grs ii had been taken, a dose which even in the human subject has been known to prove fatal. When fully oxidized it would only yield grs X of the anhydrous acid, ~~an~~ form of acid which would not ~~be~~ ~~formed~~ result in the blood as the tribasic would in all probability ~~be the result~~ arise. But a full oxidation into Phosphoric acid might not result, Phosphorous might be formed, and part of the metalloid might even remain unacted on, so that the comparatively small amount of grs X would not result. Even that, in the mass of the blood, forming as it would do, various salts would be productive of little bad consequence. It would either be assimilated by the muscles, or, if superfluous would be eliminated by the emunctories.

The blood would require to be more or less highly charged with the acid in order that by its action it could give rise to any change in its vital properties or functions. And even when this condition is fulfilled the injurious effect does not seem to follow.

I have ~~destroyed dogs by~~ administering ed to dogs grs 150 of the strong glacial acid, a form of acid

having much stronger properties than that of any, which owed by chemical process result in the blood, and equivalent to that which would require 3ij of Phosphorus fully oxidized to give rise to its production.

In such cases after 48 hours the animals seemed so ill that they had to be "put out" - the dose not being sufficient to cause death within that period - a period in which death from one fortieth the quantity of Phosphorus usually, would only too surely have resulted. The blood corpuscles on examination were found unchanged - no degeneration of the Heart had occurred and altho' in one case the Liver was slightly affected - so very slight was the change that it was less perceptible than that found in one instance where death had occurred in a much shorter period of time and had arisen from the administration of only a few grains of the Metalloid.

The reaction of the blood in all cases was alkaline altho' the acid state of all the other secretions including the Bile* afforded I think sufficient proof of its having actually entered the system.

* In no other cases did I see the Hepatic Secretion altered in reaction.

Grains 35 of the same form of acid dissolved in a small quantity of water was thrown very soon into the veins. by no means disagreeable. This subsequently injected gave rise to no phenomena altho' several days were allowed to elapse. equal strength & doses to grains 15 of the metalloid.

In cases where the acid is prescribed as a tonic though much diluted, still the quantity daily taken cannot be less in many instances than the total equivalent to a dose of Phosphorus which would not only prove injurious but even fatal in its result.

Those who work at the manufacture of the lucifer matches, and in whom necrosis of the jaw and chronic bronchitis evidence the pleiny the injurious action of the vapours of Phosphoric acid inhaled. only in them a slow but a certainly fatal blood change seemed to take place. if the Phosphoric acid has really such a powerful effect on the elements of the circulating fluid. Nature has thus, as a partly depuration been known described as occurring in them, and certainly had it been the case it would not so long have remained undescribed.

the slow, almost chronic character of the secondary effects in some cases gives some slight credence to the acids and not the Phosphorus itself being the cause — but we must recollect many circumstances, might cause a process which even in the most favourable is very slow, to be retarded and that Phosphorus alone, unless undergoing an oxidation, or ~~some~~ other change is an inert substance.

From a consideration of these facts I considered it very improbable that Phosphoric Acid could be looked upon as the toxemic agent, and I am the more convinced of it by the result of one or two experiments which I performed — In one case it was given by the Stomach, death resulted in a comparatively short time and on a p.m. abundant evidence was found of its power to act injuriously on the Gastric Mucous membrane — in the others the subcutaneous injection was practised — in all death had to be produced by other means — and only in one was there any fatty degeneration present. In none could I detect any alteration in the blood.

My own idea is that the Phosphorus itself while undergoing oxidation is the true cause of the blood changes which we have seen seem to be so characteristic and which I believe may be looked upon as themselves giving rise to the phenomena about which so much has been said and written.

This change also is the explanation of the Pneumonia and Bronchitis which we have seen are not uncommon lesions in such cases - acid vapors have not been long known to be capable of causing inflammatory action in the organs of Respiration - The pulmonary apoplexy is no doubt the result of the disorganized condition of the blood.

The only other point which I must refer to here is the idea of Phosphuretted Hydrogen being the causa morbi - That it cannot be formed in sufficient quantity in the intestinal canal I think has been sufficiently [illegible] - but may it not result in the blood.? May the Phosphites and Hypophosphites which were formed there and which undoubtedly will into the circulation may they not meet with nascent Hydrogen as they flow with the current of the circulation

and may the gas not unite? It may, but as in the other case when considering it poisoning. I stated - it must be small in amount.

That it has external to the body a marked influence on the blood I have satisfied myself.

Mialhe, imagines it unites with the Iron in the blood to form of Phosphuret of Iron.

Bellini denies this and states in support of his opinion that after passing Phosphuretted Hydrogen through the blood, the corpuscles remained unchanged. I have repeated his experiment twice and with the following results. I passed for some time streams of the gas through blood. It was in one case firmly coagulated when the process was begun altho' drawn from the bloodvessel five minutes before - gradually the coagula were broken down, the colour changed to a deep black, and the corpuscles on examination were found irregular in outline and seemed darker in colour.

In a day or two it assumed a treacly consistence but the coagulation never reappeared.

In the other experiment by means of a pipette introduced through the Jugular Vein blood was drawn directly from the right side of the Heart.

and the gas which was placed in a recess was allowed to act upon it for nearly 48 hours. It had assumed at the end of that time a dark colour and became tacky in its consistance. It became known gradually thicker and assumed at last an appearance not unlike that of "printers ~~cork~~ rollers" certainly as firm and tenacious. The corpuscles were irregular and haematoidine crystals were distinctly at one time visible in it. One marked point was that it readily absorbed the gas which even water takes up to a very slight extent.

From these facts then I am rather inclined to think that if Phosphuretted Hydrogen be formed (and this is by no means improbable) it will play a part, and a not unimportant part in the production of these changes in the blood which we have seen are so characteristic of Phosphorus poisoning.

Having now considered that part of the subject which in a great measure although in many points amply supported by facts is to a considerable extent theoretical, we shall now pass to the Pathology -

Part III

Pathology

The Pathalogy of Acute Phosphorous poisoning is certainly one of the most interesting as it is one of the most extraordinary points in the consideration of the action and effect of this remarkable poison. What tends to lend an additional and a more feeling source of interest to any subject of this kind is the fact that it has been but little investigated and that consequently it remains somewhat obscure. The mere appearances of a p.m. have been noticed, the case detailed but few or no suggestions are given as to the probable cause of these appearances; ~~and~~ Certainly it is the grand basis of all sound pathalogy ~~as~~ that it does not look alone to the morbid anatomy of any disease but that it should enquire into the various ways in which such morbid phenomena are likely to be produced, pointing out these ways, thus leading to a perfect knowledge of the subject and enabling means to be taken which should combat such influences and so prevent the development of the organic change.

That remarkable changes do take place in the course of the action of Phosphorous on the living tissues can be little doubted. Many cases have been detailed and many of the most eminent pathologists

Of the present day bear home this testimony to the fact that such metamorphisis do occur.

In investigating the pathology of any given disease its morbid anatomy ought justly undoubtedly to claim our attention. Accurate and complete observations in the structural changes which a disease induces in the system cannot be over valued, whilst on the other hand the information in this way afforded gives but a very imperfect notion of its true pathology.

In the following section I am having already described the Symptomatology and the Morbid anatomy I shall confine to the conditions which in all probability give rise to both.

The fatty degeneration or the second point in the pathology of phosphorus poisoning I shall mainly consider, but I shall at the same time try to point out its relation to those blood changes with which a I believe it is very intimately associated.

Much has been said and written of fatty degeneration, much that is true, and perhaps much that has not been substantiated still there is no denying the fact that under certain circumstances and in certain situations it is apt to occur.

Has the fact of the fatty degeneration of the tissues as a result of Phosphorus poisoning been demonstrated?

Some minds ~~who~~ have a distrust, or profess to have in the so called "fashion of the day" imagine that too much has been made of this pathological change, and in the instance of Phosphorus poisoning where it has at various times been described as the principal lesion found, still greater doubts have been expressed - whether tainted with this idea or not I cannot say but on entering upon this enquiry and performing the experiments I have already referred to so often, and which I shall record more fully hereafter, I certainly was influenced by the idea of its very great improbability - now however my opinion is completely changed and ~~little doubt~~ no doubt exists with me as to its actual occurrence. The interesting and somewhat important point to determine is its cause and several theories have been put forth in explanation - theories which fail to explain it but which I shall consider in detail.

I and as might have been anticipated was the idea of an improper aeration of the Blood from the Respiratory function becoming involved

This requires no comment - its utter impracticability as explaining the Fatty Liver in Phthisis has been so often demonstrated that it is unnecessary to refer to it here.

II That it arose from an inflammatory action in the part excited by the contact of the Phosphorus or its compounds — this was the theory of Lewin.

Though inflammatory action excited in any way may be the cause of fatty degeneration as proved by the investigations of Paget and Rokitansky, still it is very rarely so — its own product not unfrequently undergo this change but the involved and affected tissues more often break down or simply waste.

Though the abnormal action promote such a change it cannot be looked upon as the true essence of it — the most marked cases of fatty degeneration of the Heart, the Liver, and the arteries, are those in which there is no trace of inflammatory action.

III That it was soluble in <u>the fat of the serum</u> and by virtue of this property exerted its action specially on the Liver.

This does not explain the fatty degeneration in the Heart. Kidneys and Muscles — parts which suffer almost equally with the Liver — so that it also does not explain it.

IV That the Phosphorus ~~exposed~~ exerted some peculiar action on the histogenetic tissues of the Liver and Kidney — they also, we are at fault as other organs as we have found likewise suffer — one thing however

may be mentioned in support of this view viz that in cases where the subcutaneous injection was practised, the parts immediately underlying presented the most marked fatty degeneration but whether this was due to the actual contact of the Phosphorus or to the oil by which it was held in solution was difficult to determine. At all events the theory I think can hardly be looked upon as explaining the primal change.

None of them seem to be able to explain the changes for which at various times they have been given out - an original one may then be stated and altho' defective in many points, yet if it tend in any way to indicate the proper quarter in which these phenomena have their origin, and lead to a more careful, more conclusive, and more accurate research it will certainly have fulfilled the wish with which it was put forth.

It is not only intended to explain the fatty degeneration but likewise the conditions which so often accompany it the hemorrhage and the jaundice - It has for its foundation, what, as far as I can find is quite an original observation

× Where?

× By whom & how?

× How so?

How does this agree with pp 88–97?

the discovery in such circumstances of haematocrystallin in the blood.

1st It has been observed by Virchow that when a solution of haematocrystallin is injected into the blood of a living animal jaundice appears and bile pigment passes into the urine.

2nd The colouring matter of the blood when acted upon by various reagents has been (lately) shown to yield a substance apparently identical with bile pigment.

3rd All causes which bring about a solution of the blood cells appear to favour the occurrence of haemorrhage.

Phosphorus when it enters the blood may be looked upon as an irritant substance, but the moment solution commences, that moment the peculiar power which it seems to exert on the blood cells begins.

This seems to be a power of dissolving & acting upon the cell wall so as to allow of the escape of its contents, of its colouring matter at all events.

This no longer enclosed in the cell floats free in the current of the blood, being in identically the same condition as that which Virchow introduced from without.

Moreover the Phosphorus unoxidized & its acids when this process is completed come in contact with it and may not they have a similar power to that of some other chemical reagents viz of converting the haemato-crystalline into bile pigment.

Thus then we have two distinct ways, or modes of action by which jaundice may be produced. This may give rise when circulating in the blood to the serious symptoms - symptoms which we see are not very unlike those occurring in Acute yellow Atrophy and where they undoubtedly depend on a similar cause.

This cell destruction or transformation may give rise to other important changes in the functions of the blood corpuscles. It may destroy their property of carrying Oxygen to the tissues, and hence give rise to a retention in the blood of the hydrocarbons the results of assimilation as well as of disintegration.

These fail ~~to be converted~~ to pass into the conditions in which under ordinary circumstances they leave the body and circulating in the mass of the blood they tend to become deposited as fat in the tissues.

The Liver is specially apt to undergo this fatty

change whether due to the fact that it has specially to act on the fatty constituents of the blood while discharging its peculiar function & to some inexplicable condition – a tendency for fatty matter to be deposited in its texture – is not easily determined – Of all other organs (the kidneys perhaps excluded) the Heart next in order presents this peculiar tendency. It is not so much to be wondered at then, that these are the very parts in which we find in Phosphorus poisoning this deposition most likely to take place.

A another reason also dependent on the change in the constitution of the blood specially of the alteration in its powers of nutrition is (if we embrace the theory of Mr Paget and look upon fatty transformation as probably one of the products of the spontaneous changes which occur in the tissues at the end of their period of vigorous existence, and that, this condition may represent the state of a tissue remaining unrepaired after it has fallen into the ordinary course of degeneration) – is that we have tissues un-repaired because the source whence their nutrition and rebuilding should come is stopped and consequently the natural state of fatty

changes into which they have fallen in the ordinary course of events remains permanent.

This is associated with the fact that a non-circulation of the fatty matter probably is presented and that the liver and kidneys by the presence of matter in the blood which is their special function to remove are over stimulated - their tissues break down, become fatty, but remain unrepaired - the tissues of the cerebellum also must for a like reason undergo a similar change - a change which would cause a later become unusual.

In this we find another reason for the appearance of Jaundice, but it is only here that a fatty change in the liver is so great as to cause a very much impaired, & complete suspension of its function.

In the third consideration with which I commenced this theory we find a sufficient explanation for the occurrence of hemorrhage.

That many of the blood cells become dissolved there can be no doubt - that this goes on in direct relation with the amount of Phosphorus undergoing oxidation there also little doubt since the very conditions are present and

in many cases increasing time by time which have been found to favour the occurrence of capillary haemorrhages and extravasations. On the ground of an altered blood, and of the presence in all probability of bile pigment in it, I would explain, those symptoms of the disordered state of the nervous system, and of nutrition, which are found not unfrequently to occur in Acute Phosphorus poisoning.

Having now stated what I cannot but regard as a not improbable hypothesis in explanation of the leading point in the pathology of this subject I must conclude, and I cannot do so without expressing my warmest thanks to Professor Maclagan for his kindness in allowing me to carry on my investigations in his Labratory, and to Dr Arthur Gamgee for his very able and very kind assistance in working many of them out.

Appendice.

In detailing the experiments I shall only refer to the points which interest us most as bearing on the subject I have just considered.
They may be divided into four Groups.

I Poisoning by Phosphorus - administered by the Stomach.

II Poisoning by Phosphorus injected subcutaneously

III Poisoning by Phosphorous acid

IV. Poisoning by Phosphoric.

In the I Group. the local as well as the general action is illustrated. whereas in Group II the general is alone.

Experiment I

To a dog I gave gr iii of Phosphorus in oil - the oesophagus was immediately tied and death occured in 48 hours.

P. M. (within 2 hours after death).

The Thoracic viscera were first examined -
The Trachea was normal - the Lungs attracted attention by the appearance of red hepatization which portions of their structure presented - the middle lobe of the right and upper lobe of left were in this condition - they were red, non crepitant and presented in every respect the appearance of Pneumonia.
The Heart was very flabby - almost pewter colored but was not pale.

How it looked is not described –

+ How shown? How was fatty, said above to be "fatty looking" –

+ Irregular corpuscles may be formed by the mode of demon-
-stration –

The right side contained a considerable quantity of dark fluid blood which was neutral or perhaps feebly alkaline in reaction. (This blood was the subject of the investigations shortly detailed in connection with the occurrence of Hæmato crystalline) Abdominal Cavity. Manual inspection revealed nothing particular beyond a patty looking lymph. The reaction of the Peritoneal fluid was feebly alkaline. The coats of the Stomach were distinctly reddened they presented however no traces of ulceration. The duodenum, jejunum. and portions of the Ileum presented in patches a distinct injection of the mucous membrane. They contained an oleaginous looking fluid, which was also found in the Stomach The Liver was fatty and congested The Kidneys much congested but not fatty The Blood on microscopic examination presented very markedly the irregular corpuscles.

Experiment II

To a full grown cat I gave on the 10th of Oct at 2 p.m. ½c of a gr of P.- It seemed well that night and next day no change was observable - its food however was noticed to be untouched. 11th Another ½ was administered. 12th gr ½ was given. 13th ¾ gr of a gr in oily solution was given.

7 of what kind? –

14th gr. i ß were given and the animal carefully watched for 2 hours after the administration but no vomiting took place.

15th. The animal is still alive - Blood was drawn from the femoral vein and was noticed to be of a bright cherry red colour and on microscopic examination showed the irregular cells - a portion of muscular fibre removed at the same time presented the fatty degeneration.

16th. gr. ii were administered but the Chloroform which had always previously been given was stopped - Death occurred next day about 2 p.m. and the sectio was made while the body was still warm.

The Oesophagus and Pharynx were normal - The mucous coat of the Stomach was slightly injected and much corrugated - the Duodenum altho' not ~~inflamed~~ inflamed presented numerous patches of ecchymosis.

The Liver and Spleen were normal.

The Kidneys were much congested but not fatty.

The Lungs were normal - both cavities of the Heart contained dark fluid blood.

Muscular Tissue had undergone degeneration.×

The Blood crystals appeared on the 11th day after the p.m. in the blood removed at that time, and were two days later in appearing in that drawn during life.

What difference is understood between "inflammatory action" and "injection"?

How shown?

Experiment III

To a full grown cat I gave three small pills of the Phosphorus paste. Death occured in 4 hours afterwards and was preceded by very rapid respiration, and great pain indicated on pressure on the abdomen.

In 3 hours the Rigor Mortis was marked.

On 40 hours after death - Rigor Mortis marked.

The Gastric mucous membrane was deeply injected with Bile and showed evidences of inflammatory action - The Duodenum was very much injected and at points, in the whole length of the part the mucous membrane had ruptured.

The Liver was congested and fatty. to a very slight extent - The Gall Bladder contained 3ss of normal Bile.

The Kidneys were much congested and fatty.

The Trachea was injected and the Lungs (especially the right) were pneumonic.

The Heart was on both sides firmly contracted but contained a small quantity of dark fluid blood in it cavities -

The Blood cells were altered in outline and after some days haematoidine crystals made their appearance.

* How about?

Experiment IV

A cat took by mistake the tip of Phosphorous which was concealed in a piece of meat.

He died 12 hours after.

P.M. (48 hours (after death) - Rigor mortis marked

The Stomach contained a quantity of thick grey mucous with black particles of extravasated blood

The mucous membrane was at some points deeply injected and minute ulcerations were found near the pyloric end.

The duodenum was also much inflamed but the remainder of the intestinal tract was normal.

The Liver was congested and fatty at one or two points.

The Kidneys were also slightly fatty.

The Lungs were hyperaemic - The trachea was pinkish

The Heart left side was distended and contained dark fluid blood.

The Blood showed the irregularly shaped corpuscles and crystals ultimately appeared in it.

The Urine was albuminous, contained, blood cells and was acid in reaction.

+Was the liver in former cases "whitish yellow" -?

Experiment V

To a cat I gave on the 5th of Oct. $\frac{1}{8}$ of a gr. of Phosphorus on the 6th $\frac{1}{6}$, on the 7th $\frac{3}{4}$ - on the 8th none - It died on the 9th at 10.30 a.m.

P.M. (4 hours after death) Rigor Mortis marked.

In examining the mouth a red line was readily discernible round the gums from which ~~both~~ before death haemorrhage had occurred

The Stomach was distended by a bloody biliary coloured mucus - There was no injection of its mucous coat but at several points were to be observed ulcerated gangrenous patches varying in size from a pin head to a large pea. At one point the muscular coat was completely exposed.

The Duodenum and a small extent of the upper part of the small bowel presented a very distinct injection - The whole length of the gut had the peculiar cord like feel to which in a previous part of the paper I have referred. Haemorrhage had evidently occurred from the mucous lining of the Rectum as that part of the bowel was filled with dark tarry blood.

The Liver was large somewhat congested and nearly $\frac{3}{4}$ths of its external surface ~~[illegible]~~ presented the whitish yellow appearance indicative of a fatty change.+

+ "No microscopic examination of former cases" – so that this is the only experiments in which it has been shown that the liver is really fatty –

+ How shown?

+ How shown?

This was fully confirmed by microscopic examination, the hepatic cells being filled with oily granules.— ×

The Gall Bladder was very full.

The Kidneys were much congested, and very fatty. ×

The Urine was albuminous, contained blood cells and crystals of the triple phosphate.

The Trachea was quite normal.

The Lungs were very much congested.

The Hearts left side was distended with dark fluid blood and its muscular fibres were fatty.

The Blood corpuscles were irregular and very pale in the colour.

Experiment VI

To a cat I gave grs x of the Phosphorus paste — death occurred in 18 hours.

P.M. Rigor mortis marked —

The Gastric mucous membrane, and part of the small intestine were injected but did not present any ulceration — they had the peculiar "cord like" feel.

Liver was soft and fatty. × Gall Bladder cont. ʒj of Bile

Kidneys were congested.

The Trachea was normal

Lungs were both at part hepatized but did

not enter in matter.

The Heart left side flabby, right contracted.
The Blood was dark and uncoagulated.
Neutral in reaction - and presented the
regular cells.

Experiment III

To a rabbit I gave the heads of 18 lucifer
matches - Death occured within 12 hours.
P.M. (3 hours after) Rigor Mortis present.
The Stomach - mucous membrane injected and
considerable ecchymosis present.
The Duodenum was also injected and at
points along the course of the intestine
inflammation patches were visible - these on
examination found to be due to part of the
match head becoming attached and acting
as a source of irritation.
The Liver and kidneys were normal.
The Trachea and Lungs were unaltered. the
Heart right side was gorged and the left
contracted.
The Blood was dark and coagulated and
presented no very marked change on
microscopic examination.

4. How shown?

Experiment VIII

To a squirrel I gave nearly two grains of phosphorus. Death resulted within 18 hours.
PM. (30 hours after) Rigor mortis marked
Stomach. The mucous walls were very much injected, and presented at several points deep ulcerations. There was a strong phosphorescent odour perceptible on opening it.
The duodenum was also injected.
The Liver was very slightly fatty at one point near the centre[+]. The Gall Bladder was nearly empty.
The Kidneys were congested but healthy.
The Trachea was normal
The Lungs were hyperaemic.
The Heart right side contained dark coagulated blood and the walls of the chambers though healthy were soft.
The Blood cells were markedly irregular and the hexagonal crystals which I have already made reference to were not long in appearing.

* How shown?

Group II

Experiment IX

On the 8th of February I injected under the skin of a large cat one c.c. of Phosphorus dissolved in oil. On the 9th it was alive but listless - on the 10th it was found dead.

Rigor mortis well marked

Trachea normal.

Lungs Right - emptied and punctated numerous patches of pulmonary apoplexy.

Left also emptied and punctuating in the empty spaces a good many small petechial patches of extravasated blood.

The Heart - right side contracted - left empty but flabby and slightly fatty.

The Stomach. At points on the mucous walls petechial extravasations were present.

Liver very large and fatty + - Gall Bladder full

Kidneys were fatty +

The Blood was incoagulable when removed from the body but became so immediately after - separating into two distinct portions a red and black - before

The reaction was neutral. The cells were irregular in shape and many of them colorless - The serum which separated in considerable amount from the blood was of a dark crimson colour but from its coagulation on the application of heat cooled

not be concentrated, so as to obtain the haemato-crystallin
On examining the point at which the injection was performed there was no sign of inflammatory action.

Experiment X

Into the cellular tissue of a Rabbit I injected gr ii of Phosphorus in an oily solution.
Death occurred within 12 hours – at a p.m. three or four hours after – Rigor Mortis was present.
Trachea normal
Lungs much congested
Heart – Both cavities were more or less distended by dark coagulated blood.
The Stomach and Intestines were normal
Liver and Kidneys congested but otherwise normal.
Blood with the exception of that in Heart was uncoagulated, of a rich crimson colour, showing corpuscular cells but no crystals – Coagulation occurred in the course of 48 hours and a richly coloured serum separated.
Ultimately very fine blood crystals were developed in it.

Experiment XI

Into the cellular tissue of a cat I injected gr ij of Phosphorus. — It died within 18 hours.

P.M. Rigor mortis extreme — No inflammatory action in the injected part.

The Trachea was normal

Lungs were congested and both presented patches of Apoplectic extravasation.

Pericardium contained serous fluid.

Heart left side empty and flabby — right contracted.

Liver was congested (nutmeg) — Gall Bladder nearly full.

Kidneys fatty.

Blood — dark and uncoagulated on removal from the body but coagulated firmly within half an hour after — It showed irregular cells but no crystals.

Experiment XII

Subcutaneously I gave a dog grs vj of Phosphorus — He remained very listless for 48 hours when other four grains were injected — within other 48 hours he died —

P.M. Rigor mortis not very well marked.

Under the skin where the injection was practised, and among the muscles of the right thigh into which a part was also thrown — large abscesses were found containing grumous looking pus smelling strongly of Phosphorus.

The Trachea was normal

The Lungs - One of them was slightly hepatized.

The Heart Both cavities were flabby and contained dark fluid blood - the walls of the left ventricle were soft and pulpy.

The Intestinal Tract was normal

The Liver was normal - the Gall Bladder nearly full

The Kidneys were congested but not fatty.

The Blood was dark and uncoagulated and the attraction in the clot element was not very marked

In this case the animal was suffering from a blood disorder Mange. and consequently was not in a favorable condition for experiment - I rather suspect that in the unhealthy constitution the injected poison acted as a source of irritation causing inflammation around it - a lymph line to be formed as in an abscess sac - and its absorption to a great degree prevented.

7 How about?

Experiment XIII

Under the skin of a very large cat I injected gr. 10 of Phosphorus in oil - It died within 18 hours.

PM (36 hours after death). From the extreme cold the body was frozen so that the Rigor Mortis was marked

The Trachea was slightly injected

The Pleural cavities contained some effusion

The Lungs were pneumonic - especially the right.

The bronchii were slightly injected and contained pretty much mucus tinged with blood.

The Pericardium contained some fluid.

The Heart right side was empty but contracted the left flabby -

The Liver was large and very slightly fatty.

The Kidneys were large, congested, and fatty.

The Blood was dark, partially coagulated and presented not only irregular cells, but well formed crystals -

Experiment XIV (omitted from Group I.

To a Guinea Pig I gave gr. iii of Phosphorus in substance - Convulsions preceded death which took place in little more than 18 hours.

PM Rigor Mortis well marked

The Gastric mucous membrane was injected and presented a number of minute ecchymotic

x How shown?

spots and was at several points particularly at the pyloric end eroded and destroyed.
The Small Intestine was at parts injected.
The Liver was soft, congested and at one point fatty.+
The Kidneys were congested and slightly fatty.+
The Gall, and Urinary bladder both contained quantities of their respective fluids.
The Trachea was normal.
The Lungs - left was nearly completely hepatized - the right showed some minute points of extravasation
The Heart - Auricles both distended with dark clot - right ventricle contained a small one - left was firmly contracted.
The Blood was everywhere dark and coagulated and showed most distinctly the irregular cells.
The peculiar blood crystals appeared in some 24 hours.
The muscular fibre was healthy - the urine contained blood cells - and the Bile only its pigment.

Group III.

Experiment XV

Under the skin over the right dorsal region of a large bull terrier I injected X centigrammes of the clear staphylococcus acid.

The animal cried and struggled a good deal during the operation and some blood which seemed to come from the corpuscles of the incision had a black tarry look.

It lived for a week - eat well - and as far as external appearances enabled one to judge did not suffer much inconvenience.

The skin over the part had a slough look and pus issued from the wound in considerable amount -

In the morning of the 7th day he was found dead.

On post mortem examination there was a large slough corresponding to the part into which the acid had been injected - the skin and other tissues were destroyed - one rib bare and slightly eroded - and the pleural cavity opened into by an aperture nearly as large as a shilling -

The tissues for two or three inches on all sides of the affected part were infiltrated with a thick very offensive smelling pus.

The Rigor Mortis was present
On opening the Thorax the right lung was observed to be collapsed and the pleura thickened - Its cavity was filled with pus.
The other lung was healthy -
The Heart. Both cavities were filled with dark fluid blood specially the right.
All the abdominal viscera were normal
The Blood was dark and uncoagulated with ~~a~~ red film on the top - On microscopic examination the corpuscles were normal and no crystallization even appeared.

Experiment XVI

On the following day I injected under the skin of a cat in the same region, I centigramme of ~~the~~ ~~same~~ [a similar specimen of] acid - It also lived exactly a week - It seemed to suffer more during that period than the dog as it had almost complete anorexia.
PM. Rigor Mortis well marked -
On Examination an extensive slough (3 × 2) was found to have occurred - extending through skin and cellular tissue but not going so deep as to expose the ~~bone~~ rib.
The same suppuration [as in the other case] had occurred in the neighbourhood.

Trachea normal
Lungs emphysematous but otherwise normal
Pericardium contained fluid.
Heart right side some flaccid than left.
The Stomach and Intestines were normal
The Liver was congested -
Kidneys normal -
Blood was uncoagulated, and of a pure crimson hue - The blood cells had undergone no change.
A serum gradually separated which was quite clear in colour - and no crystallization was occasioned.

Experiment XVII.

Into the stomach of a cat I injected 5ʃ of weak Phosphorous acid - The dose was repeated in three days and the animal died in 48 hours.
PM.
The oesophagus was normal, but the stomach on its smaller curvature and near the pyloric orifice presented many duplications - in one case nearly reaching the peritoneal coat - The walls of the viscera were also much injected - The duodenum was also ~~injected~~ injected but the other parts of the Intestinal tract were healthy.

+ Low, Rowan?

The Liver was congested and slightly fatty.
The Gall Bladder contained a good deal of bile.
The Kidneys were congested but non-fatty.
The Urine contained a considerable number of blood corpuscles and triple Phosphate crystals.
The Blood - was uncoagulated when removed but after would separated into two portions red, and black - Microscopic examination displayed no change in the blood cells but the small needle shaped crystals appeared - not known the true hæmatoidin
The Trachea was normal
The Lungs were also normal.
The Heart - The right side contained a large white clot, and the left contained some dark blood.)

Experiment XVIII

I injected into the stomach of a cat about grammes x of a strong watery solution of Glacial Phosphoric Acid - Death occurred within 18 hours.

PM. Rigor Mortis extreme

The Stomach - The mucous walls were very much eroded exactly as if it had been struck by small shot, so minute but so distinct were the ulcerations. Numerous ecchymotic spots were also present.

The Duodenum was at one point injected and filled with bilious coloured mucus.

The Small Intestine contained a considerable quantity of bloody looking matter - the Colon was also injected.

The Liver, Spleen and Kidneys were healthy and the Gall Bladder contained a considerable quantity of bile alkaline in reaction

The Trachea normal

The Lungs were somewhat congested

The Heart seemed marked with recent lymph and both cavities contained firm black coagula - with small vegetation looking bodies attached to the lining membrane.

The blood was alkaline in reaction and under the microscope no change in the shape of the corpuscles was discernible.

Group IV

Experiment XVIII

I injected into the stomach of a cat about grammes x of a strong watery solution of Glacial Phosphoric acid - Death occurred within 18 hours.

PM. Rigor mortis extreme

The Stomach - The mucous walls were very much eroded exactly as if it had been struck by small shot, so minute but so distinct were the ulcerations. Numerous ecchymotic spots were also present.

The Duodenum was at one point injected and filled with bilious coloured mucus.

The Small Intestine contained a considerable quantity of bloody looking matter - the Colon was also injected.

The Liver, Spleen and Kidneys were healthy and the Gall Bladder contained a considerable quantity of Bile alkaline in reaction

The Trachea normal

The Lungs were somewhat congested

The Heart seemed marked with recent lymph and both cavities contained firm black coagula - with small vegetation looking bodies attached to the lining membrane.

The blood was alkaline in reaction and under the microscope no change in the shape of the corpuscles was discernible.

Experiment XIX

Under the skin of a Guinea Pig I injected 3ℓ of a syrupy solution of Glacial Phosphoric Acid.

The animal died a good deal during the operation, seemed wonderfully well after it and died within 18 hours.

PM (20 hours after death)

Rigor Mortis not well marked.

There was at the point of injection evidence of inflammation action and the cellular tissue was acid in reaction - A remarkable PM. change from its action had taken place the whole of the tissues with which it had come in contact having a tanned appearance and being quite pervious to the fluid - The skin, part of the intestine, and some small parts of the lung which came in immediate contact with the parietes had also suffered this change.

The Trachea was normal.

The Lungs normal - no congestion

The Heart - had both sides gorged with dark coagulated blood.

The Stomach and Intestines were quite normal except the appearance I have already described.

Y Low shown?

The Lungs were apparently quite healthy but at post had suffered from the contact of the acid.

The Kidneys were congested - not fatty.

Urine - acid - non albuminuria - no triple phosphate crystals.

The Blood - Blood cells were quite normal - but after the addition of a little water and allowing it to rest for 24 hours, crystals became apparent.

Experiment XX

Under the skin of a large dog I injected 150 grs of Glacial Phosphoric acid.

It was destroyed at the end of 48 hours.

PM. Rigor Mortis present

All the organs were healthy, with the exception of the Lungs which were congested and very slightly fatty.

The Blood cells were quite normal and after I preserved it for a considerable time no crystals appeared.

Here is now detailed as many of my experiments as I think are sufficient to illustrate the subject - without referring to them all - I close.

Plate I

Fig I represents the irregular margin of the cells.
Fig II The hæmato-crystallin as it first appears (b). (a) represents the needle shaped phosphatic crystals with which it may be compounded.
Fig III. IV. V & VI represent it at different stages of development.

Plate II

Fig I. Shows its appearance in the blood of the Guinea Pig.
Fig II the same in the Squirrel.
Fig III & IV are illustrations of the path described in Muscular Fibre.