MICRO-CHEMISTRY OF POISONS, INCLUDING THEIR PHYSIOLOGICAL, PATHOLOGICAL, AND LEGAL RELATIONS; WITH AN APPENDIX ON THE DETECTION AND MICROSCOPIC DISCRIMINATION OF BLOOD. Adapted to the use of the Medical Jurist, Physician, and General Chemist. By THEODORE G. WORMLEY, M.D., Ph.D., LL.D., Professor of Chemistry and Toxicology in the Medical Department of the University of Pennsylvania. Second edition. 8vo. pp. 784. Philadelphia: J. B. Lippincott Company, 1885.

THE second edition of Professor Wormley's well-known treatise contains some valuable additions, but the scope and design remain unchanged. The most important of the additions, we are told in the preface, consist of illustrative cases, new tests and methods, and an appendix on the discrimination of blood. Numberless other improvements are, however, to be found in the text.

It may be said at once that the book is invaluable, and, indeed, absolutely essential to every toxicologist. It is no mere *rechauffé* of the labors of others, but is crowded with records of the personal work of the author, work which was much wanted, which required great patience as well as skill for its execution, and for which every scientific man must feel grateful. So great indeed is the value of the book, that the reviewer feels tempted to speak only of its merits and to ignore its defects. But it is necessary to say that it is very incomplete. It should have been smaller, or much larger, and in either case its practical utility would have been enhanced. The author might have confined himself to the subjects indicated by his title, and given us, with his admirable microscopic drawings, a complete account of the uses of the microscope in toxicology, and of limits of delicacy in chemical tests. Or, conferring a still greater boon, he might, as he evidently could, have made the book a complete manual of toxicology. As it is, the deficiencies are as obvious as its merits. Many poisons of great importance are omitted altogether, and many details with regard to other poisons which should appear in a complete treatise are absent. On the other hand, space might have been saved by the curtailment of purely chemical descriptions found in every text-book; as, for instance, in the pages devoted to the chemical properties of sulphuric acid and phosphorus. Among the omissions, we find poisons as important as the barium and chromium compounds, carbolic acid, nitro-benzene, chloral, colchicum, cantharides, ergot, savin, and croton, not to speak of the paraffins and terpines. In regard to several of these poisons, Professor Wormley's careful observations would have been very useful.

The introductory section of the book deals, as usual, with definitions, classifications, sources of evidence, general methods, and the like. It seems to present no particular points of novelty. The classification adopted into irritants, narcotics, and narcotico-irritants, is by no means perfect, but is perhaps as good as any other. An interesting case illustrating the effect of opium and quinine in delaying the action of strychnine is given on page 39. Although three grains of strychnine were taken, no serious effects followed for twelve hours, and death only occurred after forty hours. In this case one drachm of opium and an unknown quantity of quinine had been taken with the strychnine.

Part I. is devoted to inorganic poisons, the mineral acids and alkalies, oxalic acid, hydrocyanic acid, phosphorus, antimony, arsenic, mercury, lead, copper, and zinc. Throughout this part, and, indeed, throughout the book, the most remarkable and useful features are the careful determinations of the limits of delicacy of each test and the illustrative plates showing the appearance under the microscope of the most important precipitates. The system adopted in determining the limit of delicacy is illustrated in the first case that occurs, the action of platinic chloride on potassium chloride (weighed as oxide). In a series of experiments, single grains of water contained $\frac{1}{50}$th, $\frac{1}{100}$th, $\frac{1}{250}$th, and $\frac{1}{500}$th of a grain of K_2O as chloride, and each was treated with platinic chloride. Even in the last case a good precipitate formed in three-quarters of an hour. With barium chloride $\frac{1}{400000}$th of a grain of sulphuric acid, and with brucine $\frac{1}{50000}$th of a grain of nitric acid were detected, the test in the last case being made in a white porcelain dish. It is also recorded that $\frac{1}{10000}$th of a grain of oxalic acid gives satisfactory crystals, visible under the microscope, when evaporated on a slide.

The section on hydrocyanic acid is, on the whole, a good one, although its value is diminished by one or two serious omissions. Many interesting cases are recorded, of which not a few are from American sources. The comparative delicacy of the silver, iron, and sulphur tests, as applied both to solutions and to vapor, are compared with care. Solutions of the poison in one grain of water gave the following results, in fractions of a grain:

	In solution.	As vapor.
By silver was detected	$\frac{1}{500}$	$\frac{1}{1000000}$
By iron was detected	$\frac{1}{10000}$	$\frac{1}{5000}$
By sulphur was detected	$\frac{1}{25000}$	$\frac{1}{10000}$

The silver test is much the most delicate, and even in solution $\frac{1}{00000}$th of a grain can be detected, but the author does not consider the proof complete unless cyanogen is actually detected on ignition. The omissions referred to above are: first, that the quantitative estimation of the acid by standard silver nitrate is not noticed, although it is very delicate and satisfactory; and, secondly, that there is no mention of essential oil of bitter almonds. The last omission is a serious one, for the crude essential oil contains, as is well known, large and variable amounts of hydrocyanic acid, and instances of poisoning by it are by no means rare. In a somewhat recent case one drachm of the crude oil, taken internally, proved fatal in an hour and a half, and it was found afterwards that not less than one grain of hydrocyanic acid was contained in the oil. The separation both of oil and acid from the contents of the stomach is easily effected. The matters, mixed with water, are rendered faintly alkaline with potash and distilled. The oil distils with the water, and can readily be identified by its smell and by its spontaneous oxidation into benzoic acid. Hippuric acid is, moreover, found in the urine in abnormal quantity. When the oil has passed over, the flask is cooled, the contents slightly acidulated and warmed in a stream of air, the hydrocyanic acid which is now evolved being received in a series of small bulbs containing a solution of potash. The detection and estimation of the acid are then, of course, easy.

The section on arsenic is one of the best in the book. Here the valuation of the tests is most excellent and the manipulations necessary for the utmost accuracy are described with great lucidity. Almost the whole of the analytical and descriptive portions deserves reproduction, and will repay attentive study. There is, to begin with, an experimental study of the solubility in water of the different varieties of white arsenic, which serves to account for the discrepancies of previous observers, although it does not explain the variations, which, indeed, are enormous. Probably definite and even, perhaps, isomeric hydrates exist which have different solubilities. The experiments would have had even greater value if the temperature at which they were made had been recorded.

Still more important is the account of Reinsch's test, which is more commonly used than any other. Its limits of delicacy are defined as follows: In each case one grain of solution containing various quantities of white arsenic was used, and a fragment of pure bright copper foil measuring $\frac{1}{10}$th by $\frac{1}{20}$th of an inch heated in it, in a thin watch-glass, after acidulation with pure hydrochloric acid. When the solution contained $\frac{1}{50000}$th of a grain of white arsenic a distinct deposit was obtained, but with $\frac{1}{100000}$th of a grain only a very slight tarnish. In the former case the copper, heated in a minute capillary retort, yielded in some cases as many as fifty crystals in each field of the microscope, each crystal well marked in form, and each measuring from the $\frac{1}{8000}$th to the $\frac{1}{10000}$th of an inch in diameter. Crystals of $\frac{1}{5000}$th of an inch diameter do not weigh more than $\frac{1}{2000000000}$th of a grain! With sulphuretted hydrogen $\frac{1}{10000}$th of a grain of white arsenic can be detected. The silver and copper tests are much less delicate. Marsh's test, on the contrary, is marvellously sensitive when the evolved gas is decomposed by heat. In one experiment $\frac{1}{50000}$th of a grain of white arsenic was detected in the presence of 5,000,000 parts of liquid. Professor Wormley doubts whether any other test known to chemistry is as delicate. Some valuable notes on the occurrence of arsenic in glass, confirmatory of the results of Dr. W. Fresenius, are appended; and also some recent cases illustrative of the admitted fact that arsenic may become diffused throughout a body when introduced *post mortem*.

The copper test for mercury is not less delicate than for arsenic. The manipulation is the same. The minute fragment of copper is heated in the same capillary retort, which need not be more than two inches long, and the beads of mercury are detected and measured by the microscope. In an extreme case $\frac{1}{500000}$th of a grain of corrosive sublimate yielded 20 mercurial globules varying in diameter from $\frac{1}{3000}$th to $\frac{1}{10000}$th of an inch. Much smaller globules can be measured on a flat surface, and with an eighth power a globule measuring $\frac{1}{25000}$th of an inch in diameter and weighing only $\frac{1}{9000000000}$th of a grain is visible. But as to the practical separation of mercury, it is found that "even under the most favorable conditions the least quantity of corrosive sublimate from which the mercury can thus be reproduced is about $\frac{1}{100000}$th, or at least $\frac{1}{500000}$th of a grain." It is to be regretted that no information is given as to the toxic action of some other mercury compounds beside corrosive sublimate. We should have been glad of the latest opinions as to the injurious action of the subchloride, the sulphite, and white precipitate. Professor Attfield found that vermilion is so inert that it can scarcely be classed among poisons, a fact of no little importance, considering how constantly it is used as a pigment.

Lead, copper, and zinc follow mercury in order of treatment. On the whole, there is little in regard to them which calls for comment. In regard to copper, it may be remarked that it is still doubtful whether its continued use in small quantities can be considered as poisonous. The question is very important, for it is notorious that copper salts have often been used to impart an attractive green color to preserve provisions, and public analysts have often been called upon to express an opinion whether a minute addition of this kind constitutes an adulteration "injurious to health." The fact that a large dose of blue vitriol is poisonous proves no more than that a similar dose of saltpetre has been known to be deadly, which no one doubts. But as to the "frequently repeated small doses" there is yet but imperfect evidence. No one seems to know what the small doses have been.

In this, as in some other parts of the book, the quantitative methods described are decidedly inferior to the qualitative. There is only one satisfactory way in which to estimate copper in an organic mixture. The mixture must be burnt completely to actual ash. Incineration to charcoal is insufficient, for the charcoal holds some of the copper with tenacity. Then the ash, dissolved in dilute sulphuric acid, filtered, and, if necessary, concentrated, must be placed in a weighed platinum basin, and either treated with pure zinc, or exposed to a voltaic current with the platinum for negative electrode. In either case the copper will adhere to the platinum, which may then be washed, dried, and reweighed.

The second part of the book is occupied exclusively with vegetable poisons, or, to be accurate, with a certain number of the more important alkaloids and the vegetable substances from which they are derived. As a matter of course, the introduction describes the various general methods by which the poisons are isolated with a view to their individual detection, and equally, as a matter of course, the method of Stas, with its subsequent modifications by Otto and others, stands first. In the main, it is an excellent process, and the systematic detection of alkaloidal poisons may be said to date from the time, 1851, when Stas's memoirs appeared. Otto's modification, which is in many cases a distinct improvement, consists, as is well known, in removing, by means of ether, fat and other substances from the acid salt of the alkaloid before the separation of the alkaloid itself. For the subsequent isolation of the alkaloid, chloroform is a more generally useful solvent than ether. In the case of morphine, amyl alcohol is a better solvent than ether. The charcoal process of Graham and Hofmann, and the interesting dialytic method of the former chemist, from which so much was once expected, are properly dismissed as inadequate for modern requirements. The great objection to dialysis is the imperfection of the septum. Fine animal membrane gives much better results than vegetable parchment, and it is not impossible that even yet some practical good to toxicology may come of dialysis. Hitherto, however, it has been practically useless.

Of much greater interest at the present time is the ingenious system devised by Dragendorff, by which mixed alkaloids and some other allied substances can be separated from one another. The substance to be examined is acidulated with sulphuric acid and extracted with water. The evaporated aqueous extract is extracted with alcohol at a low temperature, and the alcohol distilled off. The concentrated acid extract is then treated, successively, with petroleum, ether, benzene, and chloroform; it is then rendered alkaline by ammonia, and again treated in turn with petroleum ether, benzene, chloroform, and amyl alcohol, which last removes morphine and some other substances which are supposed to have been left untouched in the previous operations.

Now, this system of Dragendorff's is easy to criticise, and it is impossible to deny the truth of some of the objections which Professor Wormley and others have pointed out. It is true that "few, if any, of the bodies are wholly insoluble in the different extracting fluids employed," and also that the evaporation with sulphuric acid is objectionable, but none the less it is valuable, not only as the first attempt at the systematic separation of alkaloids, but also, and much more, as affording a kind of synopsis of separative methods. That it does not enable us to analyze perfectly a mixture containing a dozen different proximate principles, some of which are present in very minute quantity, must be freely admitted, but such cases do not often occur, and when they do, we have no better method to fall back upon.

The poisons described in the succeeding pages are nearly all well known, and are sufficiently indicated by the titles of the six chapters. These are: Volatile alkaloids (nicotine, conine); Opium; Nux vomica; Aconitine; Atropine and Daturine; Veratrine, Vervine, and Solanine; and Gelsemine. The deficiencies of this list are obvious, and it must be hoped that, at any rate, the more important omissions will be rectified in the next edition, which will certainly be wanted before long. The history, as far as it goes, is good. A great many cases are quoted which will be requoted in future trials, and the tests recommended have, in the great majority of cases, been subjected to careful personal trial by the author. The section devoted to strychnine is a good sample of the whole. The limit of delicacy of the well-known bichromate test is thus stated: $\frac{1}{1000000}$th of a grain of the alkaloid is easily detected, and if due care be taken to concentrate the solution on one point of the basin, and to add the bichromate suddenly and in very minute quantity to that point, previously touched with sulphuric acid, an even smaller quantity can be found.

In Chapter IV. nearly twenty pages are devoted to aconitine, which, since the Lamson trial, has been very interesting. Some account, but not a very full or perfect one, is given of Dr. Wright's researches. No satisfactory chemical test for the alkaloid has as yet been obtained.

The chapter on gelsemium, added in the new edition, possesses additional interest because Professor Wormley himself, in 1870, showed the nature of the active principle. The yellow jasmine (*gelsemium sempervirens*), and particularly the root bark of the plant, contain a very poisonous alkaloid called gelsemine, and a non-nitrogenous acid, gelsemic acid, which was at one time erroneously supposed to be æsculin. A decoction of the bark is rendered alkaline with ammonia, agitated with ether, and the ethereal extract carefully treated with hydrochloric acid, when the hydrochlorate of the alkaloid separates in characteristic crystals. By evaporation, the acid can then be obtained from the ethereal solution in tufts, which can be purified by crystallization from alcohol. Both the alkaloid and acid appear to be poisonous, the former in an eminent degree. Fortunately, both are easily detected: the former by a bluish-green coloration, which is produced after treatment with nitric acid and spontaneous evaporation, and by a blue color produced, as in the strychnine test, by the action of sulphuric acid and potassium dichromate. From the author's description, however, it would appear that the latter reaction must be due to some impurity, for he tells us that it no longer occurs if the sulphuric acid has been warmed with the alkaloid, although the alkali itself is not destroyed (p. 695). The acid in the pure state, and, still more strongly, in alkaline solution, gives an intense blue fluorescence, which no doubt led to its being mistaken for æsculin. The acid requires 2912 parts of cold water for solution, but is soluble without change in sulphuric acid as well as in alcohol, ether, and chloroform. From the sulphuric solution, ammonia throws down the acid in crystalline needles very easy to identify. Professor Wormley gives a drawing of the crystals obtained by the addition of ammonia to a drop of solution containing only $\frac{1}{1000}$th of a grain of the acid. Altogether it appears that the secret poisoner had better avoid yellow jasmine.

With gelsemium the toxicological portion of the book ends; but in the new edition there is an appendix of forty pages on Blood: its composition, detection, and discrimination; which is important, not only for the epitome which it offers of our present knowledge, but also on account of the careful work which the author has accomplished in his own laboratory, and which is here fully described. In the following summary it will not be necessary in every case to distinguish between original observations and those of other workers.

After a general account of the nature and properties of blood in which the size and form of the corpuscles are slightly noticed, the action of water and reagents on red corpuscles is described, and the modern view in regard to the nature of those bodies explained. Unfortunately, neither here nor in the subsequent pages is the author able to solve that most important problem, the differentiation of human from other mammalian blood. It is well known that in man and all mammalia, except the camel tribe, the corpuscles are circular and non-nucleated. In the camel they are oval, but still non-nucleated; but in birds, reptiles, and fishes they have a distinct nucleus, are almost invariably oval, and are much larger. Then comes the question of identification of blood, which is discussed under the heads of chemical and optical tests, with a final section on the examination of dried blood.

Of the chemical tests enumerated, the only ones of practical importance are the well-known hæmin and guaiacum reactions. When the blood is in solution a drop is evaporated, mixed with a trace of common salt and a drop of acetic acid, and again evaporated and gently heated till it is reddish-brown. The mass then exhibits under the microscope crystals of hæmin (hydrochlorate of hæmatin, according to Hoppe-Seyler), which are very characteristic. The guaiacum is very delicate. The following case is recorded from the author's experience:

A piece of muslin one-tenth of an inch square, containing a moderate blood stain of ten years' standing, was macerated with a few drops of water for a few hours. The liquid, which had acquired only a faint reddish hue, was then decanted and evaporated spontaneously, when it left a smooth ring-like deposit of a faint reddish-yellow color. This, under the action of the test (fresh alcoholic tincture of guaiacum, followed by ethereal solution of hydrogen peroxide), immediately assumed a deep blue color. So, also, a minute portion of a single thread of the soaked material immediately acquired a deep blue color on the application of the reagents" (page 10).

In a subsequent paragraph we are warned that the reagents should be added separately; that the guaiacum alone should produce no color; and that, after the addition of the hydrogen peroxide, the blue coloration should appear "very promptly."

The optical tests are described at length, and include, not only the spectroscopic examination, but also the measurement of corpuscles, about which so much has been written. The discoveries of Hoppe-Seyler and Stokes are first described, and also the Sorby micro-spectroscope. In one of Mr. Sorby's beautiful little barometer-tube cells it is very easy to get a distinct spectrum with a solution that contains only $\frac{1}{1000}$th part of its weight of recent blood. Mr. Sorby, indeed, obtained a faint spectrum from a single blood corpuscle. The methæmoglobin and hæmatin spectra, acid, alkaline, and reduced, are also described; and these, as well as the other blood-spectra, are illustrated by a chromo-lithograph. It would have been better if the absorption bands had also been given in wave-lengths. In the examination of blood stains, it is, of course, possible that hæmoglobin, methæmoglobin, or hæmatin may be found, any one of them being equally conclusive proof of the presence of blood. With a very minute spectrum of hæmoglobin we are advised to convert into hæmatin with citric acid and afterwards reduce with iron salt. In that way three characteristic spectra can be obtained. No mention is made of Dragendorff's proposal to use borax solution for the removal of blood stains. It has, however, much to recommend it.

Not less important than the spectroscopic tests, although, unfortunately, not so generally applicable, are measurements of the size of corpuscles. After describing the methods of preparing blood-clots, new and old, for the microscope, Professor Wormley discusses the limit of determining differences and the methods of microscopic measurement. For mounting the sample and obtaining an even distribution, he recommends the method of Professor Johnston, of Baltimore, which consists in dipping the ground end of one slide in the blood to be examined and drawing it obliquely along another or along a cover. In the latter case the cover will, of course, be placed on a clean glass slide. The mean size can only be calculated from the very laborious measurement of a great many corpuscles. In the first series described, 500 corpuscles of human blood were measured, with the following results:

385,	or 77.0	per cent.,	were from	$\frac{1}{3077}$	to	$\frac{1}{3380}$	of an inch.
42,	" 8.4	"	"	$\frac{1}{3380}$	"	$\frac{1}{3636}$	" "
20,	" 4.0	"	"	$\frac{1}{3636}$	"	$\frac{1}{4000}$	" "
49,	" 9.8	"	"	$\frac{1}{4000}$	"	$\frac{1}{2898}$	" "
4,	" 0.8	"	"	$\frac{1}{2898}$	"	$\frac{1}{3817}$	" "

with an average of $\frac{1}{3285}$th of an inch. Two other series from different samples of blood gave results which are practically identical. Under certain circumstances the average sizes of the corpuscles may be slightly less than the above fraction, but they never increase.

Then follow tables in which the author's measurements of the corpuscles of various mammals, birds, reptiles, batrachians, and fishes are compared with those obtained in the classical researches of Gulliver. In very few cases is there any important difference, the most notable being with regard to the opossum. A very useful microscopic chart illustrates this part of the book by showing the comparative apparent size of the blood corpuscles of several important animals under equal microscopic power. The whole study leads inevitably to a conclusion which must be stated in the author's own words:

> "The microscope may enable us to determine with great certainty that a blood is *not* that of a certain animal, and is *consistent* with the blood of man; but in no instance does it, in itself, enable us to say that the blood is really human, or indicate from what particular species of animal it was derived."

In conclusion, it must be said that the microscopic drawings are not only of remarkable beauty, but, judging from well-known cases, of great accuracy; and, as their scale is given in every case, and minute directions for reproducing the originals, they have the highest value. They were all executed, we are told, by Mrs. Wormley, to whom the book is most appropriately dedicated, and who has earned the thanks of every scientific man.

C. W. H.