om, large doses seem to act directly upon the heart muscle, the animals dying within ten to twenty minutes with dyspnœa and convulsions. Some investigators explain these symptoms as the consequence of general muscular paralysis (Santesson); others, as a paralysis of the central nervous organs (Van Denburgh). A faint hæmolysis is noticed *in vitro*, but in the body no effect upon the blood is visible, no exudation or hemorrhage appears. The local symptoms, with rare exceptions, are entirely wanting; it is even difficult to find the spot where the venom has been injected. Yet it ought not to be forgotten that a few cases of persons bitten by a heloderma are on record in which extensive and painful local swelling is noted.

The autopsy shows nothing but a very much dilated heart and an enormous venous congestion of all internal organs. The microscopical examination of the spinal cord, however, reveals extensive changes in the ganglion cells of the anterior horns; in fact, Bailey found the changes almost identical with those described as due to the action of snake venom. It is not hard to believe, therefore, that snake venom and the saliva of heloderma are almost identical in chemical composition. Santesson has demonstrated that this saliva contains albumoses as well as some nuclein bodies, the latter perhaps responsible for the slight action upon the blood.

Treatment.—It is to be expected that the persons bitten by a heloderma will seldom exhibit grave symptoms, except when accidentally a blood-vessel has been struck directly. A treatment after general surgical principles will suffice to subdue the local phenomena, while the organism has time to overcome the effects of the injected toxin. Yet a ligature ought not to be omitted, and otherwise the use of antivenomous serum should be resorted to as well. The similarity of the toxins of snake venom and the saliva of heloderma justifies the administration of the same antidote. Calmette even claims for his antivenomous serum the same success in stings of scorpions as for snake-bite.

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POISONS.—A concise definition of the term poison, which will satisfy the medical, the legal, and the popular acceptations, is a practical impossibility. To the layman a poison is any substance which, when administered in small doses, causes disturbance to health or destruction of life; in a legal sense it is any substance of a destructive or noxious character, whatsoever its nature or mode of operation, which, taken into the system, produces injurious or fatal effects. The popular definition excludes many well-recognized poisons which act injuriously only in large doses; the legal includes, or may be made to include, many substances not strictly poisonous, such as powdered glass, iron filings, and other things of a similar character, which are merely mechanical irritants. To the physician and toxicologist the term means any substance of inherent deleterious character, either organic or inorganic, and incapable of self-reproduction, which, acting chemically upon the tissues or fluids of the body, may, by causing alteration or destruction of the same, or disturbance of function, seriously affect the health or destroy life. This definition excludes mechanical agencies, direct thermal changes, electricity, bacteria, and the low forms of animal life.

The published statistics of poisoning are very meagre, but the few tables which we have are interesting in several ways, indicating the classes of substances and special substances most frequently selected or accidentally administered, at different times and in different countries, and showing the proportion of accidental, suicidal, and criminal deaths due to poisoning.

The returns made by the English coroners of the inquests held during 1837 and 1838 showed the whole number of deaths by poisoning to be 541. Of this number opium was the cause in 196 cases, the majority of which were accidental or suicidal. Arsenic stood next in order, with 185 cases, the majority of which were criminal. Thirty-two cases were due to sulphuric acid, 27 to prussic acid, 19 to oxalic acid, and 15 to corrosive sublimate and other preparations of mercury.

During the years 1863 to 1867 there occurred in England and Wales 2,097 deaths from poison. Of this number no less than 628 were due to opium and its preparations, 151 to prussic acid and potassic cyanide, 83 to arsenic, 77 to mineral acids, 66 to oxalic acid, 61 to strychnine, 58 to compounds of mercury, 15 to phosphorus, and 11 to ammonia.

In France, during the years 1851 to 1871, out of 873 cases, 287 were due to arsenic, 267 to phosphorus, 159 to copper, 36 to sulphuric acid, 35 to cantharides, while opium and its preparations were responsible for but 6.

In Finland, of 30 fatal cases occurring between 1860 and 1866, arsenic caused 7, phosphorus 5, and strychnine 4.

Out of 45 cases reported in Massachusetts during the period 1878 to 1881, opium was responsible for 18, arsenic for 13, and all others for 14.

Although poisoning is a frequent means of suicide, the percentage of these cases is not nearly so high as is generally supposed; but yet, judging from what figures we have been able to obtain, this method of terminating an unsatisfactory existence is gradually becoming more popular. In Prussia, for instance, while there was a great increase in the number of suicides from all causes during the period 1871 to 1876, the relative frequency of self-poisoning was very much greater. The increase from all causes over preceding years was 43.60 per cent., but suicide from poisoning alone had more than doubled in frequency, the increase being 126.10 per cent.; but, even then, poisoning was the means employed by but a fraction over three per cent. of the whole number of suicides. During the eight years ending with 1876, the whole number of these cases was 24,918, and of this number 786 were by poisoning (3.15 per cent.). Solid or liquid poisons were elected by 707 persons, and gaseous by 79. It is interesting to note further that, while by far the greater number of suicides were men, the proportion being 80.50 against 19.50, or more than 4 to 1, the 786 suicides by poisons were nearly evenly divided between the two sexes, the proportion being 52.9 men to 47.1 women.

Of the whole number of suicides reported in Bavaria during the fourteen years ending with 1870, 2 per cent. were due to poisoning. In 1871 the percentage increased to 3.2; during 1872 it was 3.00; in 1873 it fell to 2.20; increased again in 1874 to 2.70, and fell off again slightly in 1875 to 2.50. The popularity of poisoning as a means of suicide varies greatly in different countries. In Sweden, from 1843 to 1855, nearly a fourth of the suicides chose this means (21.7 per cent.); in England, in 1858 and 1859, 9.10 per cent.; and in other countries as follows: France, 1835–44, 2.48 per cent.; 1848–57, 1.80 per cent.; Belgium, 1840–49, 1.80 per cent.; Denmark, 1840–56, 1.50 per cent.; Würtemberg, 1857–70, 1.20 per cent.; Geneva, 1838–55, 4.90 per cent.

Of the accidental deaths occurring in Prussia during the years 1869–76, 54,363 in number, 2,448, or 4.50 per cent., were due to poison. This number includes 1,873 men and 575 women; 348 of the victims were under and 2,100 over fifteen years of age. During the fifteen years ending with 1877 there were 77 cases of criminal poisoning in Prussia, or 0.056 per cent. of all crimes. In France, during 1826–29, out of 2,663 capital offences, 150, or 5.63 per cent., were for poisoning. In England and Wales, during 1840, there occurred 349 deaths from poisoning (181 men, 168 women); 161 cases were suicidal (74 men, 87 women); and 188 were accidental and homicidal (107 men, 81 women). Among the latter, opium caused the death in 42 children under five years of age.

CLASSIFICATION.—Various methods of classification of poisons have from time to time been recommended; but no system has as yet proved wholly satisfactory. The old classifications, according to source or chemical properties, such as: (1) animal; (2) mineral; (3) vegetable; or, (1) organic; (2) inorganic; or (1) acids; (2) alkalies; (3) salts, are of no value, since they convey no idea regarding the properties of a poison or its mode of action. Orfila's division into (1) irritants; (2) narcotics, and (3) narcotico-irritants; Tardieu's into (1) irritants and corrosives; (2) hyposthenìants; (3) stupefacients; (4) narcotics, and (5) tetanics; and Taylor's into (1) irritants, and (2) neurotics, are all good; but each has its defective points. Taylor's is, perhaps, the best. The irritants are derived from the animal, vegetable, and mineral kingdoms; those from the latter source may be further subdivided into acid, alkaline, non-metallic, and metallic. The neurotics are subdivided into (1) cerebral; (2) spinal; (3) cerebro-spinal, and (4) cerebro-cardiac.

The irritant poisons include many which are also corrosive in their action, causing disintegration of the parts with which they come in contact. The pure irritants exert no such chemical action, and are much slower in the development of symptoms. They cause irritation and inflammation of the parts to which they are applied, with violent vomiting and purging, intense pain, and well-marked effects on the nervous system. These symptoms occur after a greater or lesser interval, according to the nature of the particular poison. The pain, which is usually of an intense burning character, is, unlike that due to colic, much increased by pressure. Septic irritants produce additional symptoms of a character formerly known as typhoidal.

The neurotic poisons act chiefly on the brain, cord, and nerves; occasionally, the symptoms manifested partake more or less of the character of irritant poisoning. Those acting chiefly on the brain, producing stupor and insensibility, preceded by fulness in the head, vertigo, impaired vision, delirium, etc., belong to the cerebral; those affecting chiefly the cord, producing tetanic or clonic convulsions, to the spinal; those producing symptoms referable to the brain and cord, to the cerebro-spinal; and those affecting the brain and heart, to the cerebro-cardiac class.

ACTION.—The action of poisons may be local, remote, or both. Local action is physical and chemical, and is manifested by inflammation, corrosion, and direct effect upon the nerves, whereby the functions of organs are impaired or destroyed. If the chemical affinity of the poison for the tissues at the point of application be not great, the result is irritation and inflammation; if, however, the affinity be great, the action is most intense, and we have actual corrosion. Remote action depends upon absorption into, and transportation by, the blood to the various organs which may be affected. Thus, for instance, digitalis affects the heart, strychnine the cord, and opium the brain. In any case of acute fatal poisoning, death is the result of the remote action of the poison, which may or may not have a local action.

The ordinary action of poisons may be modified by the size of the dose, by the chemical combination of the substance, by the state of aggregation or admixture, by the condition or absorptive power of the part or membrane to which it is applied, by the condition of the patient, by habit, and by idiosyncrasy. The young and old are more susceptible, as a rule, than the middle-aged; women more than men; and fasting more than well-fed persons. Disease also may render the subject less susceptible, or, on the other hand, may facilitate the action of the poison. Habit diminishes the effect of many poisons, so that a much larger dose is required for the manifestation of symptoms than would be for persons not so habituated. Idiosyncrasy is a peculiar condition of the system which enables harmless substances to produce violent symptoms similar to those of irritant poisons. Thus many persons are unable to eat certain articles of food, even unknowingly—such as shell-fish, fish, strawberries, some kinds of meat, butter, honey, and other things. In the same way, many persons are seriously affected by small medicinal doses of opium, strychnine, arsenic, and other pharmaceutical preparations. A second form of idiosyncrasy is a tolerance for exceptionally large doses of poison by persons in no way protected by the influence of habit.

ABSORPTION.—In order to produce poisonous symptoms, the presence of a certain amount of poison in the blood is usually necessary, and the amount required depends upon rapidity of absorption and of elimination. A certain amount of any poison in the blood is incapable of producing any symptoms. Beyond this is that amount which is capable of producing characteristic symptoms—the poisonous dose; then that amount capable of destroying life—the minimum fatal dose; and beyond this up to a certain point, the action is increased in violence and rapidity. The poisonous and minimum fatal doses are relatively large if absorption is slow and elimination rapid, and small if the latter conditions are reversed. The rapidity of absorption depends greatly upon the physical properties of the poison; liquids are more rapidly absorbable than solids, soluble solids more than insoluble, and gases more than liquids or solids. Some insoluble solids may be rendered soluble, and hence more absorbable, by the action of the juices of the stomach and intestines.

Poisons may be taken into the system directly through the blood, as in absorption from wounds or injection into blood-vessels; they may be absorbed through the skin or from the cellular membrane, from inflamed serous surfaces, and from all mucous membranes. Absorption directly into the blood from wounds occurs with great rapidity. Through healthy skin covered with cuticle, absorption is very slow and in small amount. It is increased by rubbing and by the addition of fatty substances or solvents of the poisons. Gaseous substances are more absorbable than watery solutions, particularly if the latter are warm or hot. On the other hand, absorption from a diseased skin is very rapid, and many fatal cases have been noted from the application of washes, ointments, and dressings to diseased surfaces.

Mucous surfaces absorb poisons in the following order of rapidity: (1) lungs; (2) stomach; (3) intestines; (4) mouth; (5) nose; (6) eyes; (7) tear passages; (8) rectum; (9) vagina; (10) uterus; (11) bladder; (12) prepuce. The mucous surfaces of the lungs and the air passages absorb poisons with great rapidity, and particularly those in the form of gas or dust. The lining membrane of the stomach and intestines is usually the absorbent surface in ordinary cases of poisoning. Fulness of these organs retards, and emptiness favors, absorption. Certain poisons which are rapidly fatal when introduced into the circulation (snake poisons, curare, etc.) are harmless in a full stomach, and, indeed, are absorbed only in small amount when that organ is empty.

Concerning the absorbent power of other mucous membranes, it is necessary only to remark that all are efficient, though in a somewhat varying degree. On account of the absorption of poisons by the mucous membranes of the intestines and bladder, it is sometimes necessary in treatment to administer cathartics, or to catheterize, in order to prevent the reabsorption of substances which are undergoing elimination from the system by the saliva, the juices of the stomach, pancreas, and intestines, the bile, or the urine.

Elimination.—As soon as absorption begins, the substance is diffused through the whole body by the circulation, and at the same time the process of elimination is begun. Coincident with this is still a third process, that of deposition in the various tissues of the body, from which, however, the poison is eventually eliminated, unless death intervenes. Deposition goes on chiefly in the liver, kidneys, spleen, brain, and heart. The effect of a poison depends upon the relative rapidity of absorption and elimination, and these processes go on with greater or lesser rapidity according to the nature of the substance. If elimination proceeds as rapidly as absorption, fatal results do not occur; but with a slower elimination the poison accumulates in the system, and, provided a sufficiently large amount has been administered, destroys life. Elimination is influenced by the chemical affinity of the poison for the constituents of the blood or of the tissues of the affected organs. If this affinity is great, the process is slow; if weak, the process is very rapid.

Gaseous and volatile poisons are excreted chiefly by the lungs; others chiefly by the kidneys, though all secretions of the body play a more or less important part in the process. Certain poisons appear to elect particular secretions, though the kidneys act in most cases as the most important organ of elimination. Thus mercury elects the salivary glands, arsenic and antimony the mucous and serous membranes, and many metallic poisons the liver.

Diagnosis of Poisoning.—The diagnosis of the administration of a poison is based on the symptoms and their course, the detection of poison in articles of food and drink or in the ejecta and excreta, on the post-mortem appearances, and on the detection of the suspected substance in the organs of the deceased. The symptoms are usually of sudden onset, in a person previously in good health, soon after eating or drinking. If several persons are affected at the same time, there is commonly a marked similarity in the symptoms. Where the poison is administered to a sick person, the diagnosis is rendered more difficult on account of symptoms already present, which may appear to be modified or exaggerated, and the phenomena of poisoning may seem to be only the natural course of the disease. Too much importance should not be attached to the fact of recent eating or drinking, since a poison may be inhaled, injected, or applied externally. The diagnosis of the particular kind of poison involved is of great importance for the determination of the treatment to be pursued, and it is therefore essential that the medical attendant should know, if possible, the exact course of the symptoms from their first appearance, the previous history of the patient, and the exact nature of any medicines which may have been administered. Owing to the similarity of symptoms of particular diseases to those produced by certain poisons, one must often exercise great care in making a differential diagnosis. The physician is often aided in forming an opinion by the moral aspect of the case.

Acute irritant poisoning may be suspected when violent purging and vomiting, accompanied by pain in the region of the stomach or complete prostration, occur in a person without some assignable natural cause. Acute neurotic poisoning manifests itself by more or less sudden symptoms referable to the nervous system, such as stupor, insensibility, delirium, or convulsions. Chronic poisoning is more difficult of diagnosis than acute or subacute, on account of the less marked character of the symptoms, which are often, or indeed usually, ascribable to natural causes.

In making a diagnosis in a case of suspected poisoning, it is to be borne in mind that symptoms may be delayed by fulness of the stomach, sleep, or intoxication, or may be modified or intensified by disease or debility. Among the diseases which may be confounded with irritant poisoning may be mentioned cholera asiatica, cholera morbus, gastritis, enteritis, gastro-enteritis, colic, peritonitis, intussusception, and dysentery; among those which may simulate neurotic poisoning are apoplexy, sunstroke, uræmia, septicæmia, epilepsy, tetanus, diseases of the brain and of the heart, pulmonary embolism, cerebro-spinal meningitis, rupture of the stomach or gall-bladder, typhoid fever, and coma of various origin.

Of very great importance in the diagnosis and subsequent treatment of poisoning is the detection of the substance in the remains of food or drink, or in the vomitus; but as it is possible, in any case of criminal poisoning, that these substances may have been removed and others substituted, or in cases of feigned poisoning that a poison may be introduced into the food remains or vomited matters, reliance cannot always be placed upon this evidence. But the detection of the poison in the urine of the patient establishes the diagnosis beyond any doubt. Yet, at the same time, it should be remembered that the non-detection in that fluid does not by any means prove its non-existence in the body.

The Treatment in cases of poisoning depends altogether upon the nature of the particular substance involved. The first indication, except when corrosives or poisons administered otherwise than by the mouth are involved, is evacuation of the stomach and administration of antidotes, stimulants, etc. (See special poisons under their appropriate heads. See also article on *Antidotes*.)

Post-mortem Indications.—It frequently happens, in cases of suspected poisoning, that an autopsy is all that is necessary clearly to establish the cause of death, particularly in cases of sudden death, which to the uneducated mind are associated usually with suspicious circumstances. The popular belief in poison as an agent of sudden death is doubtless, in great part, due to works of fiction and the stage, where the interval occurring between the swallowing of the poison and the termination of life is so short that the two events are almost simultaneous. As a matter of fact, sudden death is much more likely to be due to disease than to poison, and, indeed, the only poison which approaches heart disease and apoplexy in rapidity of fatal effect is anhydrous prussic acid, a poison not easily obtainable. But, in consequence of the popular tendency to associate the two ideas, innocent persons frequently are suspected or accused of a heinous crime, which may be easily disproved by the appearances on section. On the other hand, with perhaps equal or greater frequency, the autopsy serves to direct suspicion or to strengthen it in cases of poisoning which have resembled disease. But it not seldom fails to throw any light whatever upon the question of the cause of death, and then a chemical examination may be required.

The external appearances indicative of poison are very few, and of no great value. Evidence of corrosive action is sometimes furnished by the skin and clothing. The presence of certain poisons may be betrayed by their odors, and of others by stains. There is nothing characteristic to be observed from the attitude of the body, rate of cooling or of decomposition, or expression of the countenance. Rigidity is usually more marked and longer continued in death from strychnine, and is often diagnostic of this poison; in other cases, no great difference is to be observed. Internal appearances vary according to the poison; they may be absent, or so slight as not to attract attention in cases of death by neurotics, or they may be very marked and characteristic where irritants, and particularly corrosives, have been employed. The chemical and physical properties of the blood

sometimes undergo marked changes; it is darkened by chloroform, ether, carbonic acid, sulphureted hydrogen, and other gases, and by prussic acid and cyanides, oxalic acid, etc.; by morphine, strychnine, and some others, it is both darkened and rendered more fluid. The greater number of mineral poisons have no effect on the blood. The blood-vessels of the brain are sometimes observed to be engorged in narcotic poisoning, but this appearance may be very slight or entirely wanting. The principal post-mortem appearances due to poison are to be found in the alimentary canal and abdominal viscera. Corrosion of any part of the alimentary canal, softening of the mucous membrane, which is changed in color and easily detached, and evidence of intense inflammation or perforation, are diagnostic of corrosive acids or alkalies, etc. In irritant poisoning, the stomach and intestines show signs of inflammation of a more or less intense character, and sometimes ulceration and perforation, thickening of the walls, or even thickening and softening. The changes produced in other organs are chiefly engorgement and fatty degeneration; the latter occurs sometimes with surprising rapidity in the liver in poisoning by arsenic and phosphorus.

The post-mortem appearances in any case of suspected poisoning will be but imperfect evidence of the presence or results of poison, unless it is possible to distinguish them without doubt from analogous appearances which may be the result of disease. Otherwise the proof of poisoning must rest on the detection of the poison in the body, or on outside evidence. The changes which may be referable to disease or to the action of irritant poisons as well, are softening, thickening, reddening, ulceration, and perforation. Softening of the walls of the stomach may be due to poison, to disease, or to post-mortem change. If it is due to poison, similar changes are usually to be found in the mouth and œsophagus; if to disease or post-mortem digestion, these additional changes are wanting. Reddening may be due to poisoning or to gastritis, gastro-enteritis, gravitation, or to contact with the liver or spleen. But these appearances are not likely to be mistaken by one accustomed to post-mortem examinations; the redness of poisoning is usually accompanied by some peculiarity of appearance which renders it readily distinguishable. Ulceration is more commonly referable to disease than to poison. When it is due to the former, the accompanying redness is confined to the immediate locality, whereas in poisoning it is more or less widely diffused. There is also a considerable difference in the symptoms. Care should be taken not to confound ulceration, which is a vital process, with corrosion, which is chemical. Perforation of any part of the alimentary canal is, like ulceration, of more common occurrence in disease than in poisoning. When due to disease perforation of the stomach is accompanied by little if any vomiting and no purging, and death is due to peritonitis. The aperture, if due to ulceration and not to corrosion, is usually small in size, and with smooth, regular edges, instead of large, rough, and irregular. Perforation from post-mortem digestion is very rare; it may be suspected from the fact that there has been no peritonitis, nor any symptom before death, to indicate such a severe process. Perforations of the œsophagus and intestines are commonly due to ulceration from the presence of a foreign body, and in such cases the latter is usually discoverable. The intestinal wall is perforated frequently in disease, as, for instance, in typhoid fever.

Chemical Examination.—When a chemical analysis of the body is deemed necessary, the greatest precautions should be observed in performing the autopsy, and in the preservation of organs and fluids. The stomach should be ligatured at both ends before removal. On its being opened the contents should be received in a clean glass or porcelain vessel, and their quantity, color, odor, reaction, and consistency, and the presence of any unusual substances should be noted; the intestines should be treated in like manner. Each organ, on removal, should be placed in a clean vessel by itself, sealed with a private seal, and labelled. Any suspicious vials or powders, and all remnants of food, vomitus, urine, or other substances connected with the case should be sealed at the same time and delivered to the chemist. In case of exhumed bodies, where decomposition has proceeded so far that the coffin is no longer entire, it is often advisable to take, in addition, a sample of earth from above and below the receptacle. On the delivery of the organs, *et cetera*, to the chemist, it is well to give also a more or less complete history of the case, in order that he may have an idea as to the nature of the poison for which he has to search. From the symptoms and post-mortem appearances, it is frequently possible to cut the work of chemical analysis down to a minimum. Failure to detect a poison in the body is by no means conclusive that death has been caused naturally, for there are many poisons which cannot be isolated. The fatal dose of many is so very small that, even if not eliminated in great part before death, its distribution over the system renders it impossible, with our as yet imperfect means, to be isolated. In such cases the proof depends on symptoms and other attendant circumstances. Nor is the presence of poison in the dead body proof that it has caused death, for it is conceivable that poisonous substances may be introduced into the body after death has already occurred, or may have been used in the process of embalming. But the discovery of the poison in the liver and other viscera, and particularly in the urine, usually indicates ante-mortem administration.. In many cases in which death is the result of chronic poisoning, it may be impossible to detect any of the substance, which, having performed its work, has been eliminated from the system. Volatile poisons also may be lost within a very short interval after death, and others may be decomposed or oxidized in the living body. In most cases, the ability to detect the poison depends upon the length of time which has elapsed after death, upon the interval between the first manifestation of symptoms and dissolution, upon the amount taken, and upon the amount remaining in the stomach and other organs when death occurs, for reasons which have been given.

Before proceeding to a chemical analysis, a careful examination of the stomach with the aid of a magnifying glass should be made. Such inspection may reveal crystals or powders admitting of ready examination, or particles of vegetable matter may be detected which may be identified from their botanical characteristics with the aid of the microscope. The organs subjected to analysis should be accurately weighed, and any peculiarities observed should be noted. It is best to divide the organs into several portions: one for preservation; one for volatile substances; one for alkaloids, etc.; one for metallic substances; and one for special poisons. The reagents and chemical apparatus used in an investigation must be free from any impurities. The work should be carried on with great precautions, and without assistance except such as is absolutely necessary; for the chemist must be prepared to swear to the identity of the organs, and to the impossibility of any tampering with his work on the part of others.

The methods of analysis to be pursued vary with the nature of the poison. Many substances require special processes for themselves alone, while others may be grouped together under a single process. It is best to look first for volatile substances which are easily lost with keeping, such as chloroform, ammonia, volatile acids, alcohol, ethereal oils, etc. The substance suspected of containing a volatile poison is rubbed up with sufficient distilled water, made acid or alkaline according to the substance sought for, and distilled; the distillate is then further examined by special tests.

The analysis for metallic compounds requires that the organic matter of the examined substances shall be destroyed, since otherwise it interferes with the characteristic reactions. For this purpose the substance is heated in an open dish, or glass flask, with chemically pure hydrochloric acid and potassic chlorate, the latter being added a little at a time until the color of the resulting liquid remains straw-yellow for half an hour after the last addition. The excess of chlorine is then driven off by prolonged heating over the water-bath, or by the passage of a stream of carbonic acid through the liquid, which is then filtered and subjected to the regular process of qualitative analysis.

The analysis for alkaloids, glucosides, etc., is one which requires great care and delicacy of manipulation. The amount present in any one case is usually very small and widely distributed, and it is, therefore, not at all surprising that an analysis for this class of poisons often yields negative results even in the best of hands, when the administration of the poison may be proved absolutely. The method of Dragendorff for this class is the one most favorably regarded. This process is briefly as follows: The tissues are cut up small and extracted with acidulated water for several hours at 40° to 50° C., strained through cloth, and filtered. The filtrate is evaporated to beginning syrupy consistence, mixed with three or four volumes of alcohol, and allowed to stand twenty-four hours. It is then filtered, the alcohol is driven off by evaporation, and the residue is transferred to a stoppered flask after being cooled and filtered. The fluid is next shaken in the flask with freshly rectified naphtha, and then allowed to stand until the two fluids separate into two layers. The naphtha is then decanted, and the process is repeated as long as a portion of the naphtha decanted each time leaves any residue on evaporation. The naphtha removes piperine, picric acid, camphor, and similar substances, a constituent of the black hellebore, ethereal oils, capsicin, carbolic acid, and decomposition products of aconite. The fluid is next shaken with benzol, which removes caffeine, cantharidin, santonin, caryophyllin, cubebine, aloetin, digitaline, colchicine, chrysammic acid, picric acid, and colocynthin. It is next shaken with chloroform, which removes cinchonine, theobromine, papaverine, narceine, picrotoxin, helleborein, digitalein, saponin, and jervine. It is then shaken with naphtha, which removes the excess of chloroform, and next is made alkaline with ammonia, and shaken again with naphtha, which removes strychnine, quinine, sabadilline, conhydrine, brucine, veratrine, emetine, coniine, lobeline, nicotine, aniline, and trimethylamine. From the alkaline fluid benzol removes atropine, hyoscyamine, strychnine, brucine, physostigmine, quinine, cinchonine, narcotine, codeine, thebaine, veratrine, sabadilline, delphinine, nepaline, aconitine, napelline, and emetine. Chloroform is then used to remove morphine, papaverine, and narceine, and amyl alcohol for morphine and solanine. The fluid is then evaporated with glass powder and extracted with chloroform, which removes curarine. These separate extracts are evaporated each in several watch-glasses, and the residues subjected to chemical and physiological tests.

Charles Harrington.

POISONS, ABSORPTION AND DISTRIBUTION OF, IN BOTH ACUTE AND CHRONIC CASES.—All poisons are absorbed. They may enter the body by various channels, but sooner or later they find their way into the circulating blood and lymph, and are then distributed in greater or less quantity throughout the body. Toxic action is directly dependent on the absorption of the poison, and the extent of action is in direct proportion to the rate of absorption. A substance in itself insoluble and indiffusible, or incapable of being rendered soluble and diffusible by the juices of the body, is incapable of being absorbed, and hence cannot be a poison.

The fact of absorption cannot now be questioned. All poisons capable of detection by chemical or other methods are found after death in the blood itself, and in parts of the body remote from the point of introduction; and this is true whether the poison has been introduced into the body through the mouth or rectum, through the lungs by inhalation in the form of vapor, by hypodermic injection, by contact with an abraded surface, or even through the sound skin.

CIRCUMSTANCES WHICH MODIFY THE ABSORPTION OF POISONS.—Obviously, one of the most important circumstances modifying the absorption of a poison is its solubility and diffusibility. Everything else being equal, the greater the solubility and diffusibility of a poison, the more rapid its absorption, and hence the more rapid its manifestation of toxic action. As a rule, the salts of the alkaloids are more soluble than the alkaloids themselves, and hence the toxic action of the former is more rapid than that of the latter. Arsenite of potash is more rapid in its action than arsenious acid; and this is due in great measure to the rapid absorption of the more soluble compound. The action of many chemical antidotes is confined wholly to the conversion of the rapidly soluble form of the poison into a compound either wholly insoluble, or insoluble to such an extent as to delay its absorption, and thus admit of its removal from the body before it has been absorbed in sufficient amount to lead to a fatal result. Thus, in poisoning with oxalic acid the exhibition of lime water in large quantities leads to the formation of calcium oxalate, a compound comparatively insoluble and hence limited in its toxic action.

Again, the absorption of a poison naturally soluble is increased by introducing it in the form of a solution. Thus arsenious oxide introduced into the stomach dissolved in water, is more rapidly absorbed than when introduced in the form of powder. Further, when dissolved in dilute alkalies, thereby being converted into a new body, it is still more rapidly absorbed, thus introducing another feature into the problem, viz., that of diffusibility. It is here much the same as it is with certain foods: in order to have absorption we must have not only solubility, but also diffusibility. Thus raw egg albumen, while readily soluble, is of little use as food until by the action of the digestive juices it is converted into *diffusible* products. Arsenious oxide, then, when dissolved in a given volume of water, is rapidly absorbed; but the same equivalent of arsenic introduced in a similar manner, in the form of an alkali arsenite, is still more rapidly absorbed by virtue of its greater diffusibility. Hence, everything else being equal, the more soluble and diffusible the form of the poison, the more rapid is its absorption, and consequently the more vigorous its toxic action.

Again, the nature of the surface to which the poison is applied modifies materially the rate of absorption. This depends mainly on vascularity; the greater the supply of blood, the more rapidly does absorption go on. Hence the introduction of a poison in the form of vapor into the lungs leads to more rapid absorption than does injection into the intestine; and similarly, the injection of a soluble poison into the intestines or vagina is ordinarily followed by more rapid absorption than when it is introduced into the stomach. While, then, the natural vascularity of an organ or tissue has some modifying influence on the absorption of a poison, the condition of the blood-vessels also exerts some influence. Fulness of the blood-vessels opposes a mechanical obstacle to absorption and this no doubt explains, in part, why it is that poisons taken on retiring at night are sometimes delayed in their action until the morning, since during sleep the withdrawal of blood from the brain leads to an accumulation in the abdominal organs, and hence retards absorption from the alimentary canal. For a similar reason, poisons taken on a full stomach are much less rapidly absorbed than when the stomach is in a comparatively empty condition. The delayed absorption incident to the former state is, of course, due in part also to the mechanical obstacle afforded by the food itself, the latter keeping the poison for a time away from the stomach walls. Hence absorption, and consequently toxic action, is most rapid when the poison is taken into an empty stomach, less rapid when taken with food, and still less rapid when taken after a hearty meal.

In considering absorption from the alimentary canal, we have to notice, further, the modifying action of the digestive juices. Insoluble substances are not directly absorbed, but many compounds, by the action of the digestive juices, are so altered that their solubility is either increased or diminished, thus modifying their ab-

sorption, and hence their toxic action. As examples of the former there are many metallic carbonates, as lead, copper, zinc, and manganese which, when taken into the stomach, may be changed by the acid of the gastric juice into soluble chlorides, so that what was in itself an insoluble and non-poisonous substance may be converted into a vigorous poison.

DISPOSITION OF THE POISON AFTER ABSORPTION.—Once entered into the circulation, there is a twofold disposition of the poison possible. Either it is deposited for a time in the various tissues and organs of the body, or else it is at once eliminated through some one or more of the various emunctories. Ordinarily, if sufficient time intervenes between the taking of the poison and death, there is a temporary deposition of the poison throughout the body—after which, however, the deposited poison is gradually redissolved and eliminated. Careful study of collected facts further shows that, as a rule, the poison is deposited in the largest amounts in the liver, kidneys, spleen, heart, lungs, muscles, brain, and bones. In other words, these organs and tissues have the power of absorbing and retaining poisons, and furthermore, this absorbing power is not the same for the different organs. Chemical analysis in poison cases, and in experiments on animals where the conditions are known with much more definiteness, clearly testifies to the accuracy of this statement. Further, variation in the conditions under which the poison is taken modifies not only absorption as a whole, as already indicated, but also the absorption by individual organs and tissues. The form of the poison; the character of the dosage, whether small and oft-repeated, or a single large one; the mode of administration, etc., all are liable to exert their own modifying influence on the absorption of the poison by the different organs. A knowledge of such modifying influence must then necessarily be of great value, especially in medico-legal cases; for in time the accumulated facts will serve as data on which to found definite conclusions concerning the form of the poison, the mode of administration, the length of time intervening before death, and many other points of a similar nature, so important in criminal cases.

In this connection, therefore, the results of the quantitative analysis of the various organs and tissues of the body in poison cases are of great importance, for, as they show the distribution of the poison under known conditions, the time may come when it will be possible to draw deductions in unknown cases from the analytical results.

During the past few years many data have been collected in this direction, a few of which may be advantageously mentioned.

Carbolic Acid.—A man swallowed 15 c.c. of an official preparation of carbolic acid (100 parts phenol + 10 parts of water), and died in fifteen minutes. With the internal organs Dr. Bischoff [1] obtained the following results:

112 gm.	of blood........	contained	0.0259 gm. phenol	= 0.0231	per cent.
1,480	" liver........	"	.6370 " "	= .0430	"
322	" kidney......	"	.2010 " "	= .0620	"
508	" heart muscle	"	.1866 " "	= .0367	"
1,445	" brain........	"	.3140 " "	= .0217	"
12.5	" urine........	"	.0014 " "	= .0112	"

This case is particularly interesting as showing how rapidly a readily soluble and diffusible substance may be absorbed, and how quickly it may be distributed throughout the body. Further, it is to be seen that the poison was, at the time of death, in position to be eliminated, having entered into the urine.

Oxalic Acid.—An unknown dose of oxalic acid, followed by death in fifteen minutes. The amounts of oxalic acid found by Dr. Bischoff were as follows:

In 2,240 gm.	stomach, intestines, etc............	2.280 gm.	oxalic acid.
" 770 "	liver..............................	.285 "	"
" 180 "	heart blood........................	.043 "	"
" 350 "	heart..............................	.020 "	"
" 290 "	kidney.............................	.014 "	"
" 40 "	urine..............................	.007 "	"
" 730 "	brain..............................	....	

Potassium Cyanide.—An unknown case of potassium cyanide. The analysis made three days after death.[2]

223 gm.	stomach and contents............	contained	0.0692 gm.	HCN.
595 "	intestines......................	"	.0186	"
122 "	intestines......................	"	.0031	"
505 "	liver...........................	"	.0170	"
138 "	heart...........................	"	.0025	"
352 "	brain...........................	"	.0144	"

Arsenic.—The case of an adult female who lived two days after taking a fatal dose, furnishes the following results reported by Dr. E. S. Wood.[3]

179 gm.	stomach......................	contained	0.0442 gm.	arsenic.
6 "	stomach contents............	"	.0097	"
490 "	intestines..................	"	.0638	"
62 "	intestines contents.........	"	.0205	"
1,227 "	liver.......................	"	.0497	"
149 "	left kidney.................	"	.0043	"
125 "	right kidney................	"	.0026	"
318 "	uterus......................	"	.00[illegible]5	"
521 "	brain.......................	"	.00[illegible]8	"

In all these cases of poisoning the order of distribution of the poison is much the same as that previously stated, the liver standing first, then the kidneys, heart, lungs, etc. In experimenting on animals, however, where the poison can be variously introduced, it has been noticed that the distribution of the absorbed poison is not always the same. It is easy to see how there might be a decided difference in an acute and chronic case of poisoning, for if elimination of the poison commences at once, it follows that the relative amount of poison contained in the liver and kidneys must necessarily be different in a chronic case than where a single large dose of the poison is taken. Again, it is not difficult to see how the *form* of the poison might modify the rate of absorption and the order of distribution. This latter fact has been clearly indicated by results obtained with arsenic, both in experiments on animals and in poison cases. Thus Scolossuboff,[4] under the impression that the muscular paralysis noticed in the extremities of animals poisoned with arsenic was accompanied by a localization of the poison in the muscles, subjected his hypothesis to the test of experiment, feeding the animals experimented on with a solution of sodium arsenite. The results obtained in this manner were all of a like nature, and in several respects different from all preconceived ideas. Thus, in one experiment with a bulldog, which had been fed for thirty-four days with the arsenite, the following amounts of absorbed arsenic were found:

100 gm.	of muscle..............	contained	0.25	mgm.	of arsenic (As).
100	" liver.................	"	2.71	"	"
100	" brain.................	"	8.85	"	"
100	" spinal cord...........	"	9.33	"	"

It is to be noticed in this experiment that the amount of arsenic in the brain is three times as great as in the liver. In another experiment, with a griffin dog, the brain contained, per 100 gm. of tissue, double the amount of arsenic contained in the muscles. In every experiment, comparatively large amounts of arsenic were found in the brain, thus giving evidence of a special localization of arsenic in nerve tissue; but this result was contrary to the experience of all toxicologists in arsenic cases. Scolossuboff gave his results to the world as characteristic of arsenic poisoning in general, without apparently considering that he was experimenting with a *form* of arsenic seldom used as a poison, and with which toxicologists had had little practical experience.

In the white oxide of arsenic (As_2O_3), the arsenic of commerce, and the form most commonly used as a poison, we have to deal with a substance but slowly soluble, while in sodium arsenite we have one of the most readily soluble and one of the most easily diffusible of the solid compounds of arsenic. If the amount of arsenic in the brain could be taken as an index of the *form* in which the poison was taken, whether as a soluble or as a comparatively insoluble compound, it would in many cases of poisoning be a point of great importance. But in order to have the point in question of any practical value, we must be certain, on the one hand, that