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 absorption, 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	"	"
" 200	"	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	"
1.8	"	heart	"	.0025	"
3.2	"	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	"	.0197	"
490	"	intestines	"	.0638	"
62	"	intestines contents	"	.0205	"
1,227	"	liver	"	.0497	"
149	"	left kidney	"	.0043	"
125	"	right kidney	"	.0025	"
318	"	uterus	"	.0015	"
521	"	brain	"	.0018	"

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

under no circumstances can the taking of the white oxide of arsenic, either in the form of powder or dissolved in water or other neutral fluids, be attended with accumulation of arsenic in the brain other than in the merest trace; while, on the other hand, the taking of a soluble arsenite should be attended with a proportionally large amount in the brain. It might be argued that in chronic cases of poisoning with arsenious oxide, where the person has for weeks or months been taking small or gradually increasing doses of the oxide, the poison might then accumulate in the brain. Such arguments have been made, but the facts at our disposal tend to show the incorrectness of such a theory. On the other hand, the use of the more soluble arsenite (and doubtless all of the other soluble salts of arsenious and arsenic acids) should be attended with a noticeable deposition of arsenic in the brain. The literature of the subject contains but little definite, the amount of arsenic in the brain being generally expressed as a mere trace or in other equally ambiguous terms; implying, however, in the generality of cases, that when present it was only in very small quantity. But recent data on this point are quite decided. E. Ludwig,[5] of Vienna, writing from a large experience on the distribution of arsenic in the organs and tissues of suicides poisoned with arsenious oxide, and likewise in the organs of dogs poisoned with the same form of arsenic, both in acute and in chronic cases, says: "In all experiments it was invariably found that most arsenic was collected in the liver, that in acute cases the kidneys also contained considerable arsenic, while the bones and brain showed but very small quantities of the poison." Ludwig, moreover, states that "in chronic poisoning with arsenic, where death does not result, the poison remains longest in the liver, while from the other organs it is excreted much earlier." Quoting one of his cases, that of a suicide, an acute case of poisoning with arsenious oxide, the following results are worthy of notice:

1,480 gm.	of liver	contained	51.90	mgm.	of arsenic (As.)
144 "	kidney	"	7.69	"	"
600 "	muscle	"	.78	"	"
1,461 "	brain	"	.59	"	"
	bones	"	only a trace.		

In 1880, the writer,[6] in conjunction with Professor Johnson, reported on two cases of poisoning with arsenious oxide, in which the poison was detected and determined in all parts of the body. In one case there was no question whatever as to the form in which the poison was taken, for a mass of the white oxide was found undissolved in the stomach itself. Here there was present in the stomach, liver, and other internal organs, 83.2 grains of the poison, while the brain contained a hardly perceptible trace of arsenic. It would thus appear that the *amount* of the poison taken has little influence on the amount absorbed by the brain. In this particular instance there was as large an amount to draw upon as is often found in cases of poisoning, yet the quantity contained in the brain could not have been much smaller and been recognizable. The length of time, however, intervening between the taking of the poison and death was probably not long, although there had been time for decided absorption by the liver and other organs. In the second case referred to, where there was decided evidence of chronic poisoning, a somewhat similar result was obtained. In this case there was present in the entire body 5.22 grains of arsenious oxide, most thoroughly and evenly distributed, even to the bones, and yet the brain contained only an unweighable trace of the poison. Again, experiments carried on in the writer's laboratory, on animals have led to the same result; whenever the animals have been fed with arsenious oxide, the amount of arsenic found in the brain has been extremely minute, while in poisoning with a soluble arsenite a much larger amount has been found in the brain. At one time it was considered that the presence of arsenic in the brain was proof positive of the ante-mortem character of the poison; that in no case would the poison, introduced into the stomach or rectum after death, find its way by osmosis to so remote a part as the brain. Sutton,[7] however, by experiments conducted on dead animals, finds that arsenic may pass by diffusion quite rapidly even to the brain. Such being the case, the only way to distinguish between ante- and post-mortem introduction of arsenic would be to determine the amount of poison contained, for example, in the outer portions of the liver, as compared with the percentage amount in the centre of the organ. Guareschi[8] has also reported on the distribution of arsenic in a case of poisoning with arsenious oxide, and he likewise found only traces of the poison in the brain. Many other cases of poisoning with the more insoluble forms of arsenic, in which the distribution of the poison has been studied, lend favor to this view, that arsenic is to be found in the brain in any quantity only when the poison has been taken in a readily soluble form. One case which came under the writer's observation is particularly important in this connection. A laboring man ate for his dinner a quantity of bean soup; almost immediately after he was seized with the ordinary symptoms of acute arsenic poisoning, and died in nine hours. The autopsy showed a marked condition of inflammation of the alimentary tract, and a chemical analysis showed 76.0 mgm. of arsenic in the liver, 0.6 mgm. in the kidney, while one-half of the entire brain contained only a recognizable trace of the poison. A portion of the soup (125 c.c.) yielded 314.6 mgm. of arsenious sulphide, while the fact that the arsenic was introduced in the form of arsenious oxide was proved by finding in the sediment from the soup an abundance of the octahedral crystals of the oxide. Such a case as this must necessarily carry considerable weight with it. Everything favored the absorption of the arsenic, yet the brain contained only the merest trace. Again, the writer has obtained like results in an acute case of poisoning with Paris green, or aceto-arsenite of copper, in which the liver (2,984 gm.) was found to contain 12.7 mgm. of arsenic; the kidneys (515 gm.), 3.4 mgm.; 735 gm. of muscle, 0.9 mgm., and the brain (1,179 gm.) only a slight trace. These results certainly indicate that the relative distribution of the poison may offer some suggestion as to the form in which the poison was administered, and that, with arsenic at least, a comparatively large amount in the brain may be indicative of a readily soluble form of the poison. In this connection, however, there are always other facts to be learned in the distribution of the poison, which may substantiate the indications obtained by analysis of the brain, and at the same time, perhaps, enable us to distinguish between an acute and a chronic case of poisoning.

It is a favorite defence in poison cases, particularly with arsenic, morphine, and some other poisons, to claim that the poison found in the body of the deceased came from some hypothetical medicine containing the poison, and which the deceased had long taken, or that the person was habituated to the daily use of the toxic agent. A study of the distribution of arsenic in acute and chronic cases of poisoning shows plainly that many times, with this poison at least, it is quite possible to decide definitely whether the poison has been for a long time in the body, taken in oft-repeated doses, or whether it has been introduced in one or two large doses.

As preliminary to a discussion of this point I will quote two results of my own experience.

(*a*) In this case there was every reason to suppose a case of chronic poisoning with arsenious oxide. The following results were obtained by analysis of the parts a year and a half after burial:

	Weight of organs. Grams.	Weight of arsenic. Grams.	Per cent.
Stomach and spleen	514	0.05359	0.01040
Kidneys	80	.00660	.00825
Liver	590	.04788	.00811
One lung and heart	441	.01454	.00329
Intestines and uterus	978	.02582	.00260
One lung and liquid from thorax	402	.00583	.00140
Bladder	73	Trace.	.....
Brain	477	Trace.	.....

	Weight of organs. Grams.	Weight of arsenic. Grams.	Per cent.
Upper arm (left)	665	.00542	.00081
Forearm "	288	.00158	.00055
Hand "	150	.00019	.00012
Lower leg (right)	1,323	.00864	.00065
Thigh "	3,160	.01635	.00051
Foot "	468	.00105	.00022
Thigh bone "	615	.00040	.00006
Transverse section of body above pelvis	1,920	.03011	.00156
Muscle and ribs from left breast	406	.00371	.00091
Abdominal muscle, right side	615	.00358	.00058

(*b*) In this case the evidence pointed to acute poisoning with some readily soluble form of arsenic. Following are the results obtained by analysis:

	Arsenic as As_2O_3. Grain.
Stomach and œsophagus*	0.158
Large and small intestines	.314
Liver (one-half)	.109
Kidneys	.029
Heart (one-fourth)	.028
Lungs and spleen (two-thirds)	.114
Brain (one-third)	.025
Diaphragm	.010
Trachea, larynx, and tongue	.081

*The internal organs were preserved separately in alcohol, hence the weights of tissue analyzed are not given.

	Weight of tissue. Grams.	Weight of arsenic. Grams.	Per cent.
Left arm	1,230	0.00609	0.00495
Right leg	4,650	.00764	.000164
Thigh bone	216	.....	.....
Transverse section of body at pelvis	4,060	.01205	.000296
Muscle from breast (right)	510	.00635	.00124
Muscle from back (left)	620	.02306	.00371

In (*a*) the total amount of arsenic was 5.26 grains, in (*b*) 3.119 grains; yet it is to be noticed in (*b*) that the brain contained a comparatively large amount of arsenic, while in (*a*) there was found only a trace. This fact, if our theories concerning absorption by the brain are correct, would imply the administration of a soluble form of the poison. Further comparison of the two series of analyses shows other noticeable points of difference which point to the same conclusion, and also throw some light on the character (acute or chronic) of the poisoning.

When there has been time for even distribution of the poison, as in chronic cases, there would seem to be no reason why one set of muscles should contain more arsenic than another, aside from such differences as might arise from differences in vascularity, etc. On the other hand, there is every reason for supposing that when death ensues only a few hours or less after the poison has been taken, the distribution might be quite irregular.

The following table shows the distribution of the arsenic through the muscle tissue in the two cases, calculated to *grains of* As_2O_3 *per pound* of tissue:

	(*a*)	(*b*)
Thigh bone	0.004	....
Leg	.033	.011
Transverse section	.109	.021
Arm	.046	.034
Muscle from breast	.063	.087
Muscle from back	....	.260
Muscle from abdomen	.040	....

In (*a*) the results, with the exception of the transverse section, show a fairly close agreement. There is not that gradual increase from nothing in the bone up to a fourth of a grain per pound as seen in (*b*). The irregular distribution of the poison in tissue of the same kind, noticed in (*b*), is certainly indicative of the arsenic having been taken but a short time before death, particularly as there was none whatever found in the bones, which fact would certainly exclude the possibility of chronic poisoning.

Again, in (*b*) the two kidneys yielded only 1.5 mgm. of metallic arsenic, while the tongue and adjacent parts (175 gm.) gave 4 mgm., and a portion of the muscles (200 gm.) gave 5.65 mgm. of metallic arsenic.

Assuming the usual order of distribution, the amount of arsenic in the kidneys in (*b*) would suggest only a proportionally smaller amount in the muscles; and yet in this particular instance the amount of arsenic contained in 620 gm. of muscle tissue is greater than the amount contained in the entire liver and kidneys together. The kidneys, however, are the organs above all others concerned in the elimination of arsenic. Elimination usually commences almost immediately, and yet in this particular case there is but 0.029 of a grain of arsenic in the kidneys, while in less than three pounds of muscle tissue there is contained half a grain of the poison. This fact would necessarily imply that elimination had but just commenced, and that consequently the poison had not been long taken. It might, perhaps, be argued that the proportionally large amount of poison contained in the muscles, as compared with the liver and kidneys, might imply chronic poisoning, but coupled with the peculiar distribution is the entire absence of arsenic from the bones. Ludwig, moreover, states that in "both acute and chronic poisoning with arsenious oxide, most arsenic is invariably found collected in the liver," and that "in chronic poisoning with arsenic, where death does not result, the poison remains longest in the liver, while from the other organs it is excreted much earlier." It is impossible, therefore, to make the results obtained in (*b*) accord with a case of chronic poisoning with arsenious oxide; and further, the amount of poison found in the brain, and the proportionally large amount in certain muscles, would apparently indicate an extremely soluble and diffusible form of arsenic as the toxic agent.

Such results as these certainly favor the belief that it is quite possible to draw definite conclusions as to whether we are dealing with an acute or a chronic case of poisoning. Further than that, it is possible, in some cases, to decide even more definitely regarding the time at which the poison was taken prior to death. In this connection, the fact to be considered most closely is the amount of poison contained in the liver, as compared with the amount present in the alimentary canal and in the different organs of the body. When arsenic, for example, is taken into the stomach, absorption by the liver through the portal circulation commences almost immediately; and, as Dr. Geoghegan[9] has plainly demonstrated, deposition of arsenic in the liver continues to increase up to about fifteen hours after the poison has been taken, after which it commences to diminish. Dogiel,[10] who has confirmed Geoghegan's results as to the time required for maximum saturation of the liver, says, "a maximum of arsenic in the liver kills the animal." The absolute amount of arsenic involved in maximum saturation of the liver must necessarily vary somewhat in different cases. Barker,[11] from his analysis of portions of the liver of Horatio Sherman, concluded that the entire liver contained nearly five grains of arsenic. In the case of Dennis Hulburt, also analyzed by Professor Barker, the liver contained over seven grains of arsenic, and it would seem as if these amounts must approach near to the maximum. When such large amounts of the poison are found in the liver, it is safe to assume that the poison must have been taken at least fifteen hours before death.

In recent cases of administration of arsenic, it has been claimed by Taylor[12] that the poison may be found in the stomach and intestines, and not in the liver or other organs. This can hardly be correct under ordinary circumstances, since death seldom results so quickly from arsenical poisoning as to prevent the absorption of at least a small trace of the poison by the liver. Dogiel,[10] who has experimented somewhat on the rapidity of absorption by the liver, found that on forcing 500 mgm. of arsenious oxide dissolved in water, into the stomach of a dog, death resulted in one hour and five minutes. In a second experiment, conducted in the same manner, death

resulted in one hour and thirty-eight minutes. In the first case the liver was found to contain 94.5 mgm. of arsenious oxide; in the second case, 137.8 mgm. Thus, judging from the amount in the liver at the end of an hour, certainly but a few minutes would have been required for the absorption of a detectable quantity of arsenic.

Arsenic having been deposited in the liver or elsewhere, gradually diminishes, and if the person should survive, entirely disappears in from two to three weeks. A case bearing directly on this point came under the writer's notice some time ago. An entire family were taken sick, directly after eating, with all the symptoms of arsenic poisoning; all of them recovered except one, a middle-aged man, who died just two weeks after partaking of the poisoned food. An autopsy was made, the internal organs were delivered to the writer for analysis, together with the various articles of food partaken of by the family at the time of their sickness. A portion of the bread (786 gm.) contained 22.7 grains of arsenious oxide, while a piece of cake (166 gm.) was found to contain 55.5 grains of arsenious oxide, thus proving the character of the poison.

Analysis of the internal organs gave the following results, showing that at the time of death elimination was nearly, but not quite, complete:

Stomach (365 gm.)	contained	0.10 mgm.	arsenic (As).
One-third liver (428 gm.)	"	.20 "	"
One kidney (283 gm.)	"	.15 "	"
One-half intestine (487 gm.)	"	.20 "	"
Thigh muscle (689 gm.)	"	.25 "	"
One-half brain (390 gm.)	"	trace "	"

Concise experiments on animals, carried out quantitatively, are capable of yielding many instructive results in reference to the relative distribution of a poison under different conditions. The writer has recently conducted a series of experiments with antimony,[13] a few of the results of which may be advantageously given, as confirmatory of some of the preceding statements.

(*a*) *Hypodermic Injection of a Solution of Tartar Emetic.*—0.120 gm. of tartar emetic was introduced under the skin (right thigh) of a cat weighing 1,262 gm. The animal died in two hours. Following is the distribution of the poison:

	Total weight. Grams.	Weight of Sb. Milligrams.	Sb. per 100 gm. of tissue. Milligrams.
Liver	52.0	6.35	12.21
Brain	27.5	.60	2.18
Heart and lungs	32	.70	2.18
Kidney	12	.15	1.25
Stomach and intestines	74	.80	1.08
Muscle from back	138	1.25	.90
	335.5	9.85	....

In a second experiment a smaller amount of tartar emetic (0.082 gm.) was injected hypodermatically, and instead of being introduced in a single dose, it was divided into three, and injected separately, several hours apart. As a result, the animal lived twenty-two hours after the first dose. The following results show the distribution of the poison:

	Total weight. Grams.	Weight of Sb. Milligrams.	Sb. per 100 gm. of tissue. Milligrams.
Kidneys	11.5	0.60	5.21
Liver	63	1.50	2.38
Brain	9	.20	2.22
Stomach and intestines	98	2.00	2.04
Heart and lungs	17	.25	1.47
Muscle from back	106	.70	.66
	304.5	5.25	....

The only difference of importance between these two cases is the element of time. As might naturally be expected, therefore, there is a more even distribution of the poison in the second case than in the first. Further, in the second case the kidneys stand first in their content of antimony, the liver contains a proportionally smaller amount—much smaller proportionally than was found in the first case. This is, of course, due to the fact that in the second case the animal had lived long enough to admit of extensive elimination, and, consequently, those parts which had originally contained the most, particularly the liver, had been drawn on to the greatest extent; so that at the time of death the excretory organs, notably the kidneys, were the richest in poison. Quite noticeable in both of these cases is the comparatively large amount of antimony in the brain—which fact would agree with the previous statements regarding absorption by the brain when a readily soluble and diffusible form of poison is used.

(*b*) *Injection of a Solution of Tartar Emetic per Rectum.*—0.24 gm. of tartar emetic, dissolved in a little water, was injected into the rectum of a rabbit, in two doses. Death resulted in about twelve hours. Following was the distribution of the poison:

	Total weight. Grams.	Weight of Sb. Milligrams.	Sb. per 100 gm. of tissue. Milligrams.
Stomach and small intestines	172	8.89	15.30
Brain	9	.40	4.40
Rectum and adjoining intestines	18	.55	3.05
Liver	54	1.60	2.96
Kidneys	13	.25	1.92
Muscle	100	1.10	1.11
Urine	20	.20	1.10
Heart and lungs	17	Trace.	....
	403	12.99	....

Perhaps the most noticeable feature of these results is the comparatively large amount of antimony contained in the stomach and small intestines; a result which, taken in conjunction with other similar ones, would appear to indicate special absorptive action on the part of the epithelial cells of these parts. The amount of antimony in the kidneys, and particularly the amount in the urine, indicates plainly that at the time of death elimination was going on rapidly; but the fact that the percentage content of antimony in the liver was greater than in the kidneys, might perhaps be taken as an indication that absorption was not completed.

(*c*) *Experiment on a Dog with Antimonious Oxide.*—A dog weighing 14.2 kgm. received, with his food, 2.073 gm. of antimonious oxide, during a period of seventeen days, in doses of from 0.032 to 0.125 gm. per day. The dog was then killed by chloroform eighteen hours after the last dose of antimony had been given. The following results show the distribution of the poison:

	Total weight. Grams.	Weight of Sb. Milligrams.	Sb. per 100 gm. of tissue. Milligrams.
Liver	452	23.7	5.24
Lungs	140	1.8	1.28
Muscle (fore-leg)	157	1.2	.76
Brain	79	.4	.50
Muscle (thigh)	200	.9	.45
Kidneys	82	.1	.12
Heart	117	Trace.	....
Blood	440	Trace.	....
	1,667	28.10	....

In this experiment, which may be termed a chronic case of poisoning with an insoluble form of antimony, the relative distribution of the poison is seen to be somewhat different from what it was in the preceding cases. First, the brain contains relatively less antimony than in

the preceding; secondly, the liver contains a noticeably large amount of the poison, while the kidneys contain only a trace. This latter result would seem to indicate that elimination was going on quite slowly; but analysis of the twenty-four hours' urine showed that the amount eliminated by the kidneys in an entire day was considerable. Thus on one day, the entire twenty-four hours' urine contained 13.5 mgm. of metallic antimony; on another day, 22.5 mgm.

With copper, Ellenburger and Hofmeister have found, by experiments on sheep,[14] that the liver contains the most copper when small doses have been regularly administered, and, further, that this organ retains the metal with the greatest tenacity, they having found it there forty-one days after the last dose. The pancreas was also found to retain the copper with nearly equal tenacity; the kidneys do not contain so much of the poison. Elimination is mainly by the bile or through the intestine. Deposition of copper in the nerve tissue is quite small, but still smaller in the muscles, though copper is to be found in the muscles after administration of copper salts. Ellenburger and Hofmeister also state that the deposition of copper is proportionally much greater if it is administered in numerous small doses, the cells then having time to absorb it.

With lead, Victor Lehmann[15] has obtained some interesting results. In his experiments the lead was introduced by hypodermic injection in the form of nitrate, the animals used being rabbits. Two of his series of results are given in full.

(*a*) 0.5 gm. of lead nitrate introduced at one dose.

(*b*) 0.01 gm. of lead nitrate introduced daily, until finally a total of 0.21 gm. of the lead salt had been injected.

Distribution of Lead in (*a*)

	Weight of the organ. Grams.	Content of lead. Milligram.	Lead per 100 gm. of tissue. Milligrams.
Liver	40	0.250	0.625
Kidneys	13	.625	4.807
Heart	3	.125	4.166
Lungs	6	.125	2.083
Intestine	16	.312	1.953
Muscle	30	.187	.625
Bones	7	.187	2.678
Brain	8	.062	.781
Bile	3	.125	4.166

Distribution of Lead in (*b*).

	Weight of the organ. Grams.	Content of lead. Milligram.	Lead per 100 gm. of tissue. Milligrams.
Liver	25	0.062	0.250
Kidneys	4	.125	3.120
Heart	5	.187	3.750
Lungs	2	.062	3.125
Intestine	7	.125	1.785
Muscle	10	.031	.312
Bones	3	.125	4.166
Brain	3	.125	4.166
Bile	2	.125	6.250

Very noticeable in both series is the small content of lead in the liver, an organ which, as a rule, contains the largest amount of absorbed poison. The relatively large amount of lead in the bile naturally suggests that the elimination of the metal takes place mainly through this channel, which would account for the small content of metal in the liver. Further, experiments conducted on rabbits show plainly that more lead is excreted in the fæces than in the urine, the lead in the former doubtless coming from the bile poured into the intestines. Quite noticeable also is the large amount of lead in the bones, which amount probably grows larger the longer the lead has time to act.

Naturally, such systematic work as has been done in studying the relative distribution of poisons has been confined mainly to mineral substances, but it is to be hoped that the time will come when there will be a collection of data embracing all poisons capable of detection by chemical means. When such a time does come, it will doubtless be found that we cannot establish any general laws regarding the relative absorption and distribution of poisons as a class, but rather that each individual poison or group of poisons will show some peculiarity characteristic of itself—which possibility, or rather probability, makes it all the more needful for us to acquire, as speedily as possible, accurate knowledge of the relative absorption and distribution of the individual poisons.

Post-mortem Imbibition of Poisons.—Ante-mortem distribution of poisons is, as we have seen, due to the carrying power of the blood and lymph. Poisons are absorbed, distributed, and temporarily deposited. Poisons may, however, travel through the *dead* body, after circulation has ceased, by a process of imbibition or diffusion, by the same method as that by which salt works its way gradually through a barrel of fresh pork when placed on the upper layers. The rate of imbition of poisons depends in large measure upon the interval elapsing between the death of the body and the introduction of the poison. Arsenic, for example, introduced into the rectum shortly after death, before the tissues have become rigid, travels with a fair degree of rapidity and in time may be found in distinct traces even in the brain and spinal cord, while in the abdominal organs the amount present may be quite large. Where a long interval elapses after death, the poison introduced post mortem travels more slowly, but even in this case it gradually penetrates to remote parts. In view of these facts, it is obvious that in cases of poisoning where a surplus of the poison remains in the gastro-intestinal tract after death, and the body is buried for some time prior to the autopsy, the apparent ante-mortem distribution of the poison is liable to modification by post-mortem imbibition. This is an important fact to be kept in mind in drawing conclusions from the analytical data, especially in cases in which a large surplus of the poison is unabsorbed. With metallic poisons, however, putrefaction may quickly put a stop to post-mortem distribution, since the formation of hydrogen sulphide from the decomposing proteid material is very liable to transform the metallic salts into insoluble sulphides, thereby preventing further migration. *R. H. Chittenden.*

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POKE ROOT AND BERRY.—*Phytolaccæ radix*, and *Phytolaccæ fructus* (U. S. P.), Scoke, Garget. These two drugs are defined respectively as "the dried root" and "the fruit" of *Phytolacca decandra* L. (fam. *Phytolaccaceæ*).

This plant is a very large perennial herb with a thick, fleshy root and bearing cylindrical racemes of dark-purple juicy berries. The root, at the crown, attains a diameter of several inches and divides into two or three large branches. It is brownish-white externally and faintly yellowish-white internally. It bears quite a close general resemblance to horseradish, a fact which has led to numerous fatal poisoning accidents. The stems, when young, are bland and juicy and are used by country people in some localities as a pot-herb. They at length attain a height of 1 to 2, in the Southern States 3 or 4 metres, are at first green, afterward red or purple,