the chlorides of the alkalies, those, severally, of sodium, ammonium, and calcium; and among the chlorides of the alkaline earths, the chloride of barium. With the single exception of mercurous chloride (calomel), the chlorides of the heavy metals are distinguished among their sister salts for comparatively free solubility and great intensity of action. The iron, gold, and zinc chlorides are, furthermore, deliquescent to a high degree. For detailed discussion of the metallic chlorides, see articles under title of the several metals, and for barium chloride, see under *Barium*. In the case of the chlorides of the alkali bases, the influence over nutrition which they derive from their chlorine element exceeds in medicinal importance what properties are due to the basic radicle. The chlorides of the alkalies, therefore, may properly be regarded as constituting a distinct group of medicines.

*Sodium Chloride:* NaCl.—Sodium chloride, well known as *common salt*, *table salt*, *sea salt*, or simply *salt*, is official in the United States Pharmacopœia as *Sodii Chloridum*, Sodium Chloride. It occurs as "colorless, transparent, cubical crystals, or a white, crystalline powder, odorless, and having a purely saline taste. Permanent in dry air. Soluble in 2.8 parts of water at 15° C. (59° F.), and in 2.5 parts of boiling water; almost insoluble in alcohol; insoluble in ether or chloroform. When heated, the salt decrepitates; at a red heat it fuses, and at a white heat it is slowly volatilized and partly decomposed. To a non-luminous flame it imparts an intense, yellow color. The aqueous solution of the salt is neutral to litmus paper" (U. S. P.). While, as described, perfectly pure sodium chloride is permanent in the air, commercial table salt, containing, as it does, variable proportions of magnesium chloride, is more or less hygroscopic, becoming damp on exposure to moist air. Salt is the principal saline ingredient of sea water, and occurs native, also, in enormous quantities as a mineral. It is obtained for commerce from salt mines, and also, to a certain extent, by evaporating the water of the sea and of saline springs.

Sodium chloride is an important normal constituent of the body fluids, and accordingly is perfectly harmless to swallow in any ordinary quantity. The only effects following its special administration are, in moderate dosage, an improvement of appetite and digestion, and probably also a quickening of assimilation and nutrition. In large single doses salt is decidedly emetic, especially if taken in a lukewarm draught. Therapeutically, it is in the first place important to remember the absolute necessity of salt in the dietary, and so to see to it that dishes for the sick-room are not made too insipid by lack of salt. Next, salt is a fairly serviceable emetic; but not sufficiently powerful for urgent requirements. Accordingly, it is used rather as an adjuvant to more active emetics, than as itself a vomiting agent. Another application of salt is its administration, dry, in quantity of a teaspoonful or so, in hemorrhage of the lungs, over which affection salt is supposed to have some control; but such use, although unobjectionable, should not be to the exclusion of more potent remedies. In the matter of external application, it is notorious that salt water is more stimulating to the skin than fresh, and that, for the purpose of the constitutional reaction to be obtained, salt baths are more serviceable than fresh, and are borne by weaklings with less danger of giving "cold." The dose of salt as an appetizer is about 0.65 gm. (gr. x.), but the dosage is obviously very indeterminable, and much may be left to individual peculiarities of taste. As an auxiliary emetic, 15–30 gm. (℥ss.–i.) should be given in a tumblerful of lukewarm water. For saline baths sea water is best, but when not available a good substitute is afforded by a three-per-cent. aqueous solution of common table-salt (a pound to four gallons). For the bathing of sensitive mucous membranes, such as the conjunctiva or the Schneiderian mucous membrane in its upper portion, a weak solution of common salt affords a fluid far less painful than simple water, for the reason that such solution approaches more nearly the normal specific gravity of the fluids of the part. Such solution should range between one-half and one per cent. in strength, but it is near enough for practical purposes to make the solution by adding to a couple of fluidounces of water as much salt as will lie on the thumb nail. For injection into the nasal cavity, the solution should be blood-warm.

*Ammonium Chloride:* $NH_4Cl$.—This salt, commercially known as *sal ammoniac*, and still often called by the old-fashioned chemical name *muriate of ammonia*, is official in the United States Pharmacopœia only in a purified condition, under the title *Ammonii Chloridum*, Ammonium Chloride. Commercial sal ammoniac is now most commonly obtained from an ammoniacal liquor that occurs as a by-product in the making of illuminating gas, and is in the form of fibrous crystalline cakes of a peculiarly tough texture, making the substance very difficult to pulverize. In this condition the salt is contaminated with chloride of iron, and has to undergo a purification therefrom to fit it for medicinal use. The purified sal ammoniac is thus obtained granulated, and presents itself as "a white, crystalline powder, without odor, having a cooling, saline taste, and permanent in the air. Soluble in three parts of water at 15° C. (59° F.), and in one part of boiling water, but almost insoluble in alcohol. On ignition the salt is completely volatilized, without charring" (U. S. P.).

Physiologically, ammonium chloride seems to combine to a certain extent the peculiar virtues of ammonia (see *Ammonia*) with those of the chlorides. In continuous full dosage it deranges the stomach and bowels, exciting vomiting and purging. Its medicinal applications have been very varied, but those which have best stood the test of well-observed experience are the use of the salt to relieve myalgia and some neuralgias, and to promote free expectoration in bronchial catarrhs in the second stage, especially in cases in which the secretion is thick, tenacious, and difficult to dislodge. By German practitioners the salt is much employed also in inflammatory affections, generally where there is some product of the inflammation whose reabsorption is desirable. The average dose of ammonium chloride is from 0.30 to 0.65 gm. (gr. v.–x.) every two or three hours. It is generally given in solution, as an ingredient of composite prescriptions, and, since its taste is very disagreeable, it is well to have a little licorice added to the mixture to disguise the flavor. *Troches of ammonium chloride* are official, each containing 0.10 gm. (gr. iss.) of the salt. Externally applied, sal ammoniac in solution is a gentle irritant, and an aqueous solution, from one to three per cent. in strength, may be used as a lotion to sluggish ulcers, etc., requiring a mildly irritant impression. A local application in respiratory catarrhs has also been devised whereby the patient inhales the salt, formed in a fine cloud in air, by an arrangement that brings together the vapors of hydrochloric acid and water of ammonia. Lastly, ammonium chloride furnishes a possible means of applying cold, since by solution in water it reduces the temperature thereof quite decidedly. Thirty-five parts each of ammonium chloride and potassium nitrate to one hundred of water will lower the temperature from ten to fifteen degrees of the Fahrenheit scale. In the absence of ice such a mixture may be put into a rubber bag and applied for purposes of refrigeration during the time that the salts are in process of dissolving.

*Calcium Chloride:* $CaCl_2$.—Calcium chloride, "rendered anhydrous by fusion at the lowest possible temperature," is official as *Calcii Chloridum*, Calcium Chloride. Such fused salt occurs in "white, slightly translucent, hard fragments, odorless, having a sharp, saline taste, and very deliquescent. Soluble at 15° C. (59° F.), in 1.5 parts of water, and in 8 parts of alcohol; in 1.5 parts of boiling alcohol, and very freely in boiling water; insoluble in ether. Below a red heat the salt fuses" (U. S. P.). Calcium chloride, because of its extreme deliquescence, must be kept in well-stoppered bottles.

This salt presents a combination of an acid and a basylous radicle, both of which are peculiarly effective in the determining of sound nutrition. Accordingly a course of calcium chloride has been found beneficial in cases of





indurated and enlarged glands, or of a manifest scrofulous cachexia, or of tabes mesenterica. In large dose the salt is a dangerous irritant. The therapeutic dose is from 0.65 to 1.30 gm. (gr. x.–xx.) taken preferably dissolved in a wineglassful of *milk* (Coghill: *The Practitioner*, vol. xix., p. 251) and after eating. *Edward Curtis.*

**CHLORINE.**—Chlorine is a greenish-yellow gas, soluble in water, possessed of a peculiar and disagreeable odor, and an intensely irritant action upon animal tissues. Even in the comparatively weak dilution of one per cent. in air chlorine excites violent spasm of the larynx, and if actually inhaled leads to irritation and inflammation of the air passages, accompanied, perhaps, by hemorrhages, and possibly followed by death. Habit, however, establishes considerable tolerance, so that workmen in bleacheries get to breathe without distress a chlorinated atmosphere impossible of respiration to one unaccustomed. Feebly chlorinated air excites only a glow of warmth in the air passages, and an increase of bronchial mucus. Taken internally, in the form of strong chlorinated solutions, chlorine is powerfully irritant and even corrosive. In poisoning by inhalation of chlorine, the sufferer should be made to breathe cautiously the fumes of ammonia, or a weak mixture of sulphureted hydrogen in air. In poisoning by swallowing, albumen should be given freely, and the lesions treated upon general medical principles.

Chlorine is valuable to the physician because of a consequence of the strong affinity of the element for hydrogen, with which body chlorine unites to form hydrochloric acid. By virtue of this affinity chlorine can decompose water, especially in the light, appropriating the hydrogen and setting free the oxygen. Such nascent oxygen is then active for oxidizing, and will attack and decompose by oxidation any organic matter that may happen to be within reach. Vegetable coloring matters and noisome products of putrefactive or fermentative processes fall particularly easy prey to active oxygen, and as a result of their oxidation the color of the one group and the smell of the other undergo complete abrogation. In a roundabout way, therefore, chlorine, in the presence of moisture, is a powerful bleacher of organic dyes and a deodorizer of organic foulness. Reasoning from the easily obtained deodorant action of chlorine, it is naturally hoped that the element may also, under the conditions that currently present themselves, oxidize and so disinfect the organic matter of particulate carriers or generators of contagium—disease germs, commonly so called. But while there is no doubt of the power of chlorine so to do, if in sufficient concentration and in the presence of moisture, yet clinical experience and exact experiments combine to prove that to disinfect a room occupied by one ill of a contagious disease, the chlorination of the air must be carried beyond the limit of respirability, and to a degree which will also determine the bleaching, more or less, of colored fabrics. Sternberg, experimenting with vaccine points, found that to destroy their potency by exposure to chlorine-charged air, a charge per volume of one-half of one per cent., perfectly maintained, was necessary, and an exposure to such atmosphere of six hours' duration.[1] Considering, however, the conditions presented by a sick-chamber, where tight closure of the room is difficult to effect and where the germs easily fall into places comparatively inaccessible, a percentage at least double the above—that is, one per cent.—should be regarded as the minimum of probable efficiency.

The therapeutic application of gaseous chlorine is to deodorize, disinfect, or both. For purposes of deodorizing simply, chlorinated lime or chlorinated soda are fairly efficient, but for aërial disinfection chlorine gas must be generated in greater volume than can conveniently be gotten from those preparations. At best, however, chlorine is inferior for this purpose to sulphur dioxide, since the latter is probably more efficient as a disinfectant, while less obnoxious to carpets and clothing. For a reasonably reliable effect, chlorine gas should be evolved in great excess of estimated minimum percentages, with the room as perfectly closed as possible, and with all articles to be disinfected as freely exposed on all sides to the atmosphere as may be. Much more commonly, however, chlorine has been used on the small scale in sick-chambers while still inhabited by the patient—a procedure which, from the point of view of genuine disinfection, is not merely futile, but leads to the positive danger of the omission of other and really potent disinfectant measures. Gaseous chlorine is most conveniently generated in considerable volume by Wiggers' method, as follows: "Mix 18 parts of finely ground common salt with 15 parts of *finely pulverized* good binoxide of manganese; put the mixture into a flask, and pour a *completely cooled* mixture of 45 parts of concentrated sulphuric acid and 21 parts of water upon it, and shake the flask; a uniform and continuous evolution of chlorine gas will soon begin, which, when slackening, may be easily increased again by *gentle* heat" (Fresenius). According to Squibb,[2] "about two hundred grains of the common salt mixture, and half a fluidounce of the sulphuric acid mixture, liberates in the course of twelve or twenty-four hours about fifty cubic inches of chlorine, giving it off pretty rapidly for the first two or three hours, and very slowly afterward." Estimating from these data, a cubic foot of chlorine requires for its yield about a pound and a quarter of the salt mixture, and a little over a pint of the acid; and, therefore, for a one-per-cent. chlorination, by volume, of the air of the average bedroom of about two thousand cubic feet capacity, twenty-five pounds of the salt mixture and about eleven quarts of the dilute acid would have to be used! And when it is remembered that the one-per-cent. impregnation thus obtained is probably the minimum of efficiency, comment is unnecessary on the common practice of setting a saucer or two, holding each a half-ounce of the salt mixture, under the sick-bed with a serious view to disinfection. All that such procedure can possibly accomplish is a slight *deodorizing*.

Locally, chlorine, applied in the form of chlorinated substances and solutions, operates as a disinfectant, detergent, and deodorant, and, by virtue of its irritant properties, also as a stimulant to healthy action in wounds and sores. The United States Pharmacopœial preparations of chlorine, available for the purposes thus suggested, are the following:

*Aqua Chlori*, Chlorine Water.—"An aqueous solution of chlorine, containing at least 0.4 per cent. of the gas" (U. S. P.). Chlorine gas, generated by the action of diluted hydrochloric acid upon black oxide of manganese, is conducted into a bottle of distilled water until the latter, after agitation, is saturated with the gas in solution. The product, from its extreme proneness to spontaneous change, must be put up in "dark, amber-colored, glass-stoppered bottles," and these completely filled and kept in a dark and cool place. Chlorine water, when freshly made, is a "clear, greenish-yellow liquid, having the suffocating odor and disagreeable taste of chlorine, and leaving no residue on evaporation. It instantly decolorizes dilute solutions of litmus, indigo, and other vegetable coloring matters" (U. S. P.). Chlorine water, especially on exposure to light, tends to lose strength by reason of the chlorine decomposing the water, and uniting with the hydrogen thereof to form hydrochloric acid; when wanted of full strength, therefore, the preparation should be freshly made.

Chlorine water is used in medicine mainly as a local application, either as a lotion for foul or indolent ulcerated surfaces upon the skin, or as a gargle in analogous conditions of the mucous membrane of the throat. If freshly made it is intolerably pungent of chlorine, and should be diluted several fold with water for use. Internally the remedy is occasionally given, generally in the so-called zymotic diseases, in the hope probably of a constitutional antiseptic action—a hope little likely to be fulfilled. From half a teaspoonful to a teaspoonful may be given at a dose, diluted with five or six volumes of water. Nothing organic should be added to the potion, such as syrup or glycerin, else the free chlorine will rap-

idly disappear as such. The dose is very disagreeable to take.

*Calx Chlorata*, Chlorinated Lime.—This is the preparation, commonly miscalled *chloride of lime*, which results from exposing calcium hydroxide (slaked lime) to chlorine gas. The lime absorbs the chlorine with the formation of a peculiar product, which by the standard of the United States Pharmacopœia should contain "not less than thirty-five per cent. of available chlorine." Chlorinated lime is in the form of "a white, or grayish-white, granular powder, exhaling the odor of hypochlorous acid, having a repulsive, saline taste, and becoming moist and gradually decomposing on exposure to air. In water or in alcohol it is only partially soluble. The aqueous solution first colors red litmus paper blue, and then bleaches it. If the salt be dissolved in diluted acetic acid, an abundance of chlorine gas is evolved, and only a trifling residue left undissolved" (U. S. P.). Chlorinated lime undergoes spontaneous change on exposure to air, and accordingly must be kept in well-closed vessels in a cool and dry place. If put up in glass-stoppered bottles, the stoppers must be guarded by a thin smear of paraffin, else they will become irremovably fixed to their seats.

The composition of chlorinated lime has proved a difficult matter to determine definitely. It has been supposed to be represented by a mixture of calcium chloride and calcium hypochlorite ($CaCl_2 + CaCl_2O_2$), but certain chemical considerations make it likely that the true composition is according to Odling's formula, viz., $CaCl_2OCl$. The important chemical reaction upon which the medical virtues of the compound rest is the ready decomposition of chlorinated lime by any acid, however weak—even carbonic acid—with the evolution of free chlorine. Hence, by mere exposure to the atmosphere, the preparation continuously disengages chlorine through attack by the carbon dioxide ever present in the air, and, if treated with an acid of any power, such as hydrochloric, nitric, acetic, etc., the yield of chlorine is prompt and decided. Medicinally, partly through its evolving free chlorine and partly by virtue of its properties while under its own form, chlorinated lime is alkaline, desiccant, irritant, deodorant, and disinfectant. It is also cheap, and so combines many qualities that make it of genuine value. Its most common employment is as a disinfectant; in which capacity for aërial disinfection its yield of chlorine is insufficient, but for direct application to solid or fluid infectious material, or for the cleansing of contaminated articles, it is excellent. Its only drawbacks are its chlorinous odor, its powerful bleaching action, and the fact that it attacks metals. As a deodorant it is very potent, operating in this service even aërially upon the foul gases, but being, of course, more efficacious if directly applied to the noisome thing itself. For use as a disinfectant or deodorant, chlorinated lime may be thrown, in bulk, and liberally, down privies, drains, or sinks, or into chamber vessels (of china or glass) before use; or strewn, before scrubbing, upon foul floors; or in solution, from one to three or four per cent. in water, used as a detergent lotion upon corpses, sloughing wounds, or strong-smelling feet or armpits, etc. In these various applications the preparation must not be applied strong to colored or delicate fabrics, lest the color be discharged and the texture injured. Apart from its mere deodorant property, chlorinated lime is serviceable in promoting healthy action in sluggish and foul sores, skin eruptions, etc. For this purpose a one-per-cent. lotion is a convenient form of application. Internally, chlorinated lime has been given as a source of chlorine, aimed to combat the morbific principle in zymotic disease. It may be given in sweetened solution, freshly mixed and in doses of from .06 to .40 gm. (gr. i. to vi.). A last and special application is the inhalation of the fumes of chlorinated lime in cases of poisoning by breathing sulphureted hydrogen, as may occur to workmen entering sewers. The gas is always immediately decomposed by the chlorine of the lime compound.

*Liquor Sodæ Chloratæ*, Solution of Chlorinated Soda; Labarraque's Solution.—This preparation is made by pouring a boiling-hot aqueous solution of sodium carbonate into a filtered aqueous solution of chlorinated lime. The sodium and calcium change places, calcium carbonate being precipitated, and a chlorinated compound of sodium analogous in composition to the pre-existing calcic compound, remaining in solution. But the sodium carbonate being ordered in excess, some of this salt, unchanged, remains in the preparation. The mixture, after filtration, is brought to standard strength by the addition of water. The product must be kept, protected from the light, in well-stoppered bottles, and if these be glass-stoppered, the stoppers should be overlaid with a thin smear of melted paraffin, else they will become irremovably fixed in their seats. Solution of chlorinated soda should contain "at least 2.6 per cent., by weight, of available chlorine." The preparation is "a clear, pale, greenish liquid, having a faint odor of chlorine, and a disagreeable, alkaline taste. Specific gravity about 1.052 at 15° C. (59° F.). The solution at first colors red litmus paper blue, and then bleaches it. The addition of hydrochloric acid to the solution causes an effervescence of chlorine and carbonic acid gas" (U. S. P.).

Chlorinated soda has, intrinsically, similar properties to chlorinated lime, and, like the latter compound, is readily decomposed by acids with the evolution of free chlorine. Its therapeutic uses are therefore the same as those of the lime compound. The solution may be used as a deodorant disinfectant, poured down drains, sinks, or into chamber vessels of crockery or glass, or, diluted from five to tenfold, employed as a detergent and gently irritant lotion to foul ulcers, skin eruptions, etc. Like chlorinated lime, this solution has been given internally in zymotic diseases, the dose being from one-half to one teaspoonful, diluted manifold with water, and repeated every two or three hours. *Edward Curtis.*

[1] Sternberg: National [U. S.] Board of Health Bulletin, vol. iii., p. 21.

[2] Squibb: Disinfectants. The Medical Record, May 1st and 15th, 1886.

**CHLOROBROM** is the registered trade name of a combination of chloralamid and bromide of potassium. This combination, which possesses the active properties of both its constituents, has been recommended by Professor Charteris, of Glasgow, as a remedy for sea-sickness. He had used it in many cases with very gratifying results. A dose is given after the stomach has been emptied of its contents; the sense of depression is relieved and nausea checked; a quiet sleep follows, from which the patient awakes relieved of all the distressing symptoms. The remedy may be prepared as follows: Chloralamid, bromide of potassium, of each ʒ iss.; water, ʒ ij.; syrup, ʒ i. One to one and a half tablespoonfuls for a dose.
*Beaumont Small.*

**CHLORODYNE.**—Chlorodine. This title has been arbitrarily applied to mixtures differing considerably in composition, none of them official in the United States Pharmacopœia. Remington has proposed the following formula: Dissolve gr. xvi. of hydrochlorate of morphine in ʒ i. of water and fl. ʒ i. of alcohol; add to this chloroform, fl. ʒ iij.; tincture of cannabis indica, fl. ʒ ij.; tincture of capsicum, ♏ xviij.; oil of peppermint, ♏ iv.; dilute hydrocyanic acid, ♏ xxiv.; and perchloric (or hydrochloric) acid, fl. ʒ ss. Each fluidrachm contains gr. i. of morphine. Oldberg gives the following as an imitation of the original chlorodyne: chloroform, 140 c.c.; ether, 35 c.c.; alcohol, 35 c.c.; molasses, 35 c.c.; purified extract of licorice, 85 gm.; hydrochlorate of morphine, 0.60 gm.; oil of peppermint, 1.20 gm.; diluted hydrocyanic acid, 70 c.c.; simple syrup, enough to make a total of 1 litre. Dissolve the morphine and the oil of peppermint in the alcohol, and add the chloroform and the ether. Triturate the extract of licorice with the syrup until dissolved, and add the molasses. Mix the syrup with the above solution, and finally add the hydrocyanic acid. The "National Formulary of Unofficial Preparations," of the American Pharmaceutical Association, offers a "chloroform anodyne" under the title *Mistura Chloroformi et Cannabis Indicæ Composita*, N. F.: Compound Mixture of Chloroform and Cannabis Indica. This preparation may be prescribed as a substitute, of definite composition, for the variable "chlorodynes." Each fluidrachm of the mixture represents about 7.5 minims of chloroform, 7.5 minims of tincture of Indian cannabis, 3.75 minims of tincture of capsicum, and gr. ¼ of morphine sulphate. It is flavored with oil of peppermint. *Edward Curtis.*





**CHLOROFORM.**—Chloroform, chemically *trichloromethane*, or *methenyl chloride*, $CHCl_3$ (formerly called *terchloride of formyl*, and, popularly, *chloric ether*), is an ethereal body at one time obtained by distilling cautiously a mixture of chlorinated lime, alcohol, and water, but now most commonly produced by the distillation of acetone with chlorinated lime. Commercial chloroform is very frequently impure, and, though unobjectionable for external medical use, or, pharmaceutically, for solvent purposes, is entirely unfit for administration by inhalation as an anæsthetic. Under the simple title *Chloroformum*, Chloroform, the United States Pharmacopœia recognizes a purified article "consisting of 99 to 99.4 per cent., by weight, of absolute chloroform, and 1 to 0.6 per cent. of alcohol." The presence of alcohol in purified chloroform is for preservative purposes, since absolutely pure chloroform is prone to spontaneous decomposition. Chloroform is "a heavy, clear, colorless, mobile and diffusible liquid, of a characteristic, ethereal odor, and a burning, sweet taste. Specific gravity not below 1.490 at 15° C. (59° F.) or 1.473 at 25° C. (77° F.). Soluble in about 200 times its volume of cold water, and, in all proportions, in alcohol, ether, benzol, benzin, and the fixed and volatile oils. Chloroform is volatile even at a low temperature, and boils at 60° to 61° C. (140° to 141.8° F.). It is not inflammable, but its heated vapor burns with a green flame." Chloroform is affected by light, and accordingly it should be kept in dark amber-colored bottles, which in turn should be well stoppered and stored in a cool dark place. Chloroform of standard quality is now readily obtainable, but nevertheless, since an impure article is positively dangerous for use as an anæsthetic, it is well for the surgeon, before using an unknown sample, to apply the following simple tests: Pour a little of the chloroform upon a clean piece of filtering paper (or blotting paper, if filtering paper be not at hand) laid upon a clean plate or saucer. Rock the plate from side to side till the chloroform is evaporated, and as the odor of the chloroform disappears there should be no adventitious smell left to follow it. Next, shake thoroughly in a test tube a portion of the chloroform with an equal volume of distilled water, and allow the two fluids to separate by standing. The upper, aqueous portion should then not redden litmus paper, nor be affected by a five-per-cent. solution of either silver nitrate or potassium iodide.

In its action upon the animal economy, chloroform combines the properties of an irritant and a specific neurotic. It is a substance of high diffusion power, and hence capable of rapid and intense action. Applied pure to the skin in such manner as to prevent its being dissipated by evaporation, chloroform excites redness and burning pain, readily followed, if the application be prolonged, by blistering. Absorbed into the blood it produces profound perversions of current physiological status, of which the most important are derangement of the cerebral faculties, beginning with emotional excitement and ending in entire unconsciousness; derangement of sensation, shown most markedly in exaltation of the hearing and dulling of the tactile sense; and derangement of motility—first tremblings, or even spasms, and exaltation of reflex activity, and, later, paresis, paralysis, absolute muscular relaxation and abolition of the reflexes, and finally, if the dose be sufficient, arrest of action of heart and lungs. As seen clinically in the inhalation of diluted chloroform vapor for the production of anæsthesia the essential phenomena present themselves as follows: Very shortly after beginning the inhalation, the subject shows emotional derangement generally analogous to that seen in alcoholic intoxication, but, as a rule, of more quiet tone. In the case of naturally calm and self-contained individuals, all expression of emotional perversion may be absent, the subject passing to perfect unconsciousness without a word or a movement. As a rule, furthermore, the period of active emotional display is short, and unconsciousness supervenes not much later than four minutes after the beginning of the inhalation. Meantime, in the matter of affection of the senses, the hearing has been excited so that noises seem enormously magnified in intensity, while the tactile sense, on the contrary, has been progressively dulled. This latter effect—anæsthesia, the most important, therapeutically, of all the effects wrought by chloroform—begins earlier and is relatively more pronounced than in intoxication by either alcohol or ether. So great is the sensory dulling, indeed, that surgical procedures, except upon the most acutely sensitive parts of the body, may be practised without pain in many cases long before muscular relaxation is complete, and even while considerable conscious intelligence remains. Motor disturbances commonly begin with a moderate degree of rigidity, which, after a flitting general tremor just as consciousness fails, quickly gives way to a condition of relaxation. During the evolution of these various phenomena the respirations have at first quickened and then slackened, until at last they have become shallow and slow; the heart has also at first quickened its pulse rate, then reassumed the normal, and later taken on a more rapid but feebler action; and the pupil has at the beginning dilated, and then contracted, and redilates only with progressive advance of the intoxication, when the coma has become dangerously profound. By the march of these various phenomena the subject is brought to a condition where consciousness is lost, the muscular system relaxed, respirations are quiet and shallow, rate and quality of pulse not far removed from the normal, the pupil is still rather contracted, and reflex winking upon touch of the conjunctiva still slightly manifested. This condition is as far as the intoxication need be carried for surgical purposes under ordinary circumstances, and should therefore be recognized as the limit of effect sought to be attained under such circumstances. If the chloroform be further pushed, the respiration becomes stertorous, the heart's action grows more rapid and weak, the pupils dilate, and all reflexes cease; and, next and last, if the inhalation still continue, pulse and breathing fail and the subject dies. Upon discontinuing a chloroform inhalation, the return to consciousness is comparatively rapid, and there is but little tendency to succeeding nausea, headache, or other malaise.

Such are, in brief, the main phenomena ordinarily seen in chloroform narcosis, but departures from this normal course may occur, of which the most notable are unnatural intensity and prolongation of the period of emotional excitement; unduly strong and persistent spasmodic symptoms, and, most important of all, sudden failure of heart and respiration. Prolonged and high excitement and strong muscular rigidity, or spasms, very commonly occur together, and are most frequent in the case of hard drinkers, who take chloroform, as they take all anæsthetics, very badly. Heart-and-lung failure, likewise, is prone to occur in just such cases, but can also happen in an inhalation progressing in perfectly normal fashion, and when so occurring, is most common in subjects in the height of health and vigor. Strong and active males in the prime of life, who take chloroform on the occasion of some trivial surgical procedure, thus constitute the class that furnishes the majority of instances of chloroform collapse. With children the accident is rare, and with parturient women rarest of all. In the latter class of subjects the presence of pain very likely counteracts any possible tendency to syncope. Collapse may occur at any stage of the narcosis, or even after the subject has wellnigh wholly recovered therefrom, but is far more common, however, in the earlier

stages, generally before consciousness is lost. It may come on quite suddenly after a brief period of faltering respiration, or it may follow great and prolonged excitement, violent struggling, or strong and continued muscular rigidity or convulsions, or vomiting.

The picture is like that of shock. Suddenly the breathing falters, and almost on the instant the pulse fails, the face blanches, the eyes glaze, bleeding from cut vessels stops (supposing an operation to be in progress), and the whole aspect is that of imminent death. Ordinarily, under prompt and proper treatment, the subject revives in a very few minutes, but occasionally he does not, and another "death from chloroform" is entered on the discredit account of surgical annals.

The determining cause of chloroform collapse is an overdose of the drug. Overdosage may come about in several ways. If the subject is an old toper, or is predisposed to heart failure by reason of shock, fatty heart, congestion of the lungs, or uræmic or septicæmic poisoning, the *normal* dose of chloroform is for him an *overdose*. Again, even in the case of a sound subject, a normal dose, in the sense of a normal chloroform strength of vapor, may lead to overdosage by reason of suddenly occurring quick and deep respirations. Such unusually rapid and full breathing always follows the giving way of a fit of rigidity or of struggling, with its attendant stoppage of breathing, and the circumstance accounts for the frequency of collapse, already noted, occurring early in the chloroformization and following a scene of excitement and struggling. Lastly, overdosage may come from an overcharge of chloroform upon the inhaler, as may easily happen where the inhaler is simply a towel or handkerchief upon which an unmeasured quantity of chloroform is dashed from time to time.

The *action* of chloroform is complex, as is the case with the ethereal narcotics generally. When blood is charged directly with chloroform, the red corpuscles shrink, and, if there be free access of air, dissolve completely in the serum, presumably as a result of oxidation of their substance. But in ordinary chloroform narcosis the percentage of chloroform in the blood is too slight to lead to any change in the blood discs. Certain of the early chloroform effects, such as coughing, holding the breath and struggling, are merely reflexes of local irritation of the air passages. But, for the rest, the essential phenomena of chloroform narcosis all result from a direct action of the poison upon the *nerve centres of the brain and spinal cord* and upon the *heart*, or its contained ganglia—an action which in the main is one of *progressive paralysis of function*. The influence, however, does not fall with equal weight upon all the parts affected. The brain is perturbed before the cord, and of the tracts of the cord, the sensory suffers earlier and more severely than the motor. The centres of the medulla succumb last, and again the motor tract resists longer than the sensory, the respiratory and vaso-motor centres holding out the very longest.

Upon the *heart*, a directly weakening influence is a characteristic action of chloroform. If chloroform vapor is blown upon the exposed heart of a frog, the organ stops beating instantly, while its musculature relaxes and refuses to respond to any kind or degree of stimulation. In ordinary chloroform narcosis, a fall of blood pressure, even possibly to zero, is a classical feature of the intoxication, and a progressive weakening and dilatation of the heart, beginning at the auricles, can be demonstrated. When the poisoning is intense, the heart beats more slowly as well as more feebly, and stops at last in diastole.

Just what is the *pathology of chloroform collapse* has been a subject of dispute for many years. Some have held it to be heart failure, pure and simple, due to direct action of the poison upon the heart or its contained ganglia, while others, though admitting that the heart suffers a direct weakening, yet maintain that there never is a primary cardiac paralysis, but that death begins always in the centres of the medulla—respiratory or vaso-motor. This latter belief received a strong impetus from its reaffirmation by the second Hyderabad Commission.* According to Hare †—himself a later experimenter with chloroform under commission from the Nizam of Hyderabad—the chain of cause and effect in chloroform collapse is *primary paralysis of the vaso-motor centre*, whereby vascular control wholly disappears, the blood collects in the veins, and the subject dies as he would die from actual hemorrhage, by failure of respiration and of heart through lack of blood to nourish the respiratory centre on the one hand, and to excite and maintain the contractions of the heart on the other.

Whatever be the true explanation of chloroform collapse, the following *clinical* points seem now to be established: In extreme chloroform narcosis the *respiratory* function always fails before the *cardiac*; but if a faltering of the breathing, when it occurs, be not detected instantly and treated promptly and properly, the associated heart failure will follow surely and swiftly and will at once imperil life. The time elapsing between failure of respiration and the succeeding failure of heart action will vary with the chloroform strength of the inhalation. If the narcosis is produced by a prolonged inhalation of low chloroform percentage, the heart may beat for two or three minutes after the breathing has stopped; but if a strong percentage is used, the one failure of function will follow upon the heels of the other so quickly that the two will seem to be simultaneous.

Chloroform has but little action on the *nerves*, or, except in the case of the heart, upon the *muscles*, unless the narcosis has been prolonged or repeated. In such latter cases, however, chloroform may cause a temporary fatty degeneration, affecting not only the muscles, but also the liver and kidneys. Ordinarily this condition disappears after a few days, but while it endures, it is obviously a possible source of danger, and indeed accounts for occasional *late* deaths after chloroform narcosis.

*Body temperature* falls during chloroform narcosis, mainly as a consequence of muscular inaction.

*Elimination* of absorbed chloroform is principally by the lungs and kidneys, and the greater bulk of the poison escapes unchanged.

The *therapeutic applications* of chloroform are *locally* as an addition to liniments for rubefaction, or, in dilute mixture, as an anodyne for the relief of itching or of surface pains; by the *stomach*, principally as an antispasmodic, notably in intestinal colics, where the power of chloroform is unrivalled; and by *inhalation*, as an antispasmodic, an anodyne, or, carried to full narcosis, as an anæsthetic in surgical procedures.

For the *local* uses of chloroform the United States Pharmacopœia offers *Linimentum Chloroformi*, Chloroform Liniment, a preparation compounded of chloroform, three parts, and soap liniment, seven parts, by measure. In continuous application as an anodyne, this liniment should be applied under some air-proof texture to prevent the dissipation of the chloroform by evaporation. Chloroform is also much used as a local anodyne in the form of an extemporaneous ointment, made by incorporating one part of chloroform with eight or nine parts of some simple fatty basis.

For *giving by the stomach*, chloroform itself may be prescribed in extemporaneous mixture with glycerin, mucilage, or syrup. The dose ranges, for an adult, from a few drops to a teaspoonful. The latter dose, however, is a large one: it will be apt to produce decided narcotic symptoms, and often, also, vomiting. If ordered by drops, it must be remembered that the drop of chloroform is unusually small, the number required to fill the measure of 4 c.c. (fl. ʒ i.) ranging from one hundred and eighty to two hundred and seventy, according to the circumstances of the dropping. Most commonly chloroform is given internally in the form of one or other of the following official preparations of the United States Pharmacopœia: *Spiritus Chloroformi*, Spirit of Chloroform. This is a solution of chloroform in alcohol of the strength

* See the Lancet for the year 1890.
† The Therapeutic Gazette, February, 1897.





of six per cent. of chloroform by measure. Dose, anywhere up to a teaspoonful, diluted in some form of mixture. *Emulsum Chloroformi*, Emulsion of Chloroform, is compounded of chloroform, expressed oil of almond, tragacanth and water, the chloroform being present in the proportion of four parts, by measure. This emulsion keeps well, dilutes smoothly with water, and so forms a convenient preparation for the giving of chloroform. Since it contains no alcohol, the dose may be proportionately greater than that of the spirit just described, and may be set at from one to two tablespoonfuls. *Aqua Chloroformi*, Chloroform Water. This is simply a saturated solution of chloroform in distilled water, and is necessarily a feeble preparation, since chloroform dissolves in water but sparingly (1 part in 200). The water may be given, by itself, in doses of one or two tablespoonfuls, but it is more commonly used as a watery menstruum in composite prescriptions, wherein the chloroform of its composition acts as a preservative.

For *administration by inhalation*, only purified chloroform of known good quality is to be used. It is most commonly employed without admixture of other substances, the vapor being breathed, diluted with air. Whether the inhalation be a few whiffs only for the relief of pain or spasm, or whether it be for the establishment of full narcosis for anæsthesia, the fundamental principle must be observed to administer the vapor *sufficiently diluted*. Air overcharged with chloroform vapor is certain and swift death to all animal life, and the proportion of admixture for human inhalation should not exceed, for *continued* use, three and a half per cent. of chloroform to air. When, therefore, chloroform is administered by the homely apparatus of a handkerchief or towel, the points should be observed not to put more than half a teaspoonful or so of the agent upon the towel at any one time, and to hold the cloth free from immediate contact with the face, so that the inhaled vapor may be mixed abundantly with air. It is in this way that brief inhalations are practised for anodyne and antispasmodic purposes. And partly, perhaps, because of their brevity, and partly because of the existence of pain on the occasion of the inhaling, accidents during such brief inhalations are rare. Accidents, however, may occur if the chloroform is *self*-administered by a subject in the recumbent posture. For in such case, if unconsciousness supervenes, the chloroform-charged handkerchief is liable to fall directly upon the upturned nose and mouth, and there to remain, delivering possibly dangerous charges of vapor to the now narcotized subject. Accordingly, self-administration never should be practised unless the subject's head is raised sufficiently so that in the event of unconsciousness the hand and handkerchief will certainly fall down and away from the face, and the inhalation thus automatically be stopped. But under any circumstances chloroform is a dangerous drug for self-use.

The giving of chloroform to the degree of *narcosis*, for *anæsthesia in surgical procedures*, is a special topic, treated in this work in the following article, to which the reader is referred.

A last mode of using chloroform medically is by *deep injection*, by means of the hypodermatic syringe, for the relief of neuralgia. About 2 c.c. (fl. ʒ ss.) is injected at a dose, but the procedure is a harsh one, severe local reaction having several times followed the practice.

In the matter of the *toxicology* of chloroform, the first point to note is that chloroform taken by swallowing, even undiluted, is much less dangerous than would be supposed. The smallest fatal dose of which the writer has read was a drachm taken by a child four years old (Taylor). Boehm ("Ziemssen's Cyclopædia") mentions half a fluidrachm as a fatal dose, but does not give the age of the subject. On the other hand, cases have been reported of recovery after doses of from half an ounce to four ounces (presumably fluidounces). The symptoms, in poisoning by swallowing, are the production of a narcosis generally similar to that induced by inhalation of chloroform, accompanied in many cases by gastric troubles due to the direct irritation of the potion. The treatment must be conducted upon general principles, since there is no chemical antidote to the drug. Belonging to the subject of toxicology is the question whether it is possible to narcotize a sleeping person by chloroform inhalation without the subject's first awakening from the natural slumber so as to become cognizant of the attempt. And from recorded cases and the results of experiments, there seems to be no doubt but what the question is to be answered in the affirmative, *if the subject is in sound sleep* when the administration is made. But otherwise the attempt will certainly be recognized.

*Edward Curtis.*

**CHLOROFORM, ETHER, AND OTHER ANÆSTHETIC AGENTS, ADMINISTRATION OF.**—Before taking up the administration of the individual anæsthetics it will be well briefly to consider certain questions of a general character relative thereto, as the choice of the anæsthetic, the preparation of the patient, etc.

In view of the marked differences which exist between the actions of the several anæsthetics, it is evident that in certain cases the conditions presented by the state of the patient, the nature of the operation, etc., may render the use of one agent more suitable than another, and it has come to be a well-recognized fact that a judicious choice of the anæsthetic, especially in cases presenting unusual features, is, to all concerned, an important factor in the satisfactory conduct of the case. In the choice of the anæsthetic the first consideration is undoubtedly the safety of the patient, and it follows that in ordinary cases that agent should be employed which will least endanger the life of the patient. Omitting the important rôle of local anæsthesia and the use of those unusual agents whose true position as to safety has not as yet been determined, we are brought to a consideration of the relative safety values of nitrous oxide, ether, and chloroform.

The statistics of anæsthesia, like other statistics, may be selected and manipulated in such a manner as to prove the particular views of a given writer whether he favors one or the other anæsthetic. Good examples of the fallacy of individual statistics or those derived from small groups of cases, are furnished by the report of Laurie, showing 50,000 consecutive chloroform administrations without a death, and that of Anstie, showing 21 deaths in 3,058 chloroform administrations. It is obvious that to determine rightly the proportion of fatalities to administrations, individual statistics and smaller groups from various reliable sources should be put together till a large mass has been formed, the deductions from which must be of the greatest possible value:

| | Administrations. | Deaths. | Rate. |
|---|---|---|---|
| Statistics collected by Julliard: | | | |
| Chloroform | 524,507 | 161 | 1 in 3,258 |
| Ether | 314,738 | 21 | 1 in 14,987 |
| Statistics collected by Ormsby: | | | |
| Chloroform | 152,260 | 53 | 1 in 2,873 |
| Ether | 92,815 | 4 | 1 in 23,204 |
| Statistics collected by Gurit in Germany from 1891 to 1897: | | | |
| Chloroform | ..... | .... | 1 in 2,039 |
| Ether | ..... | .... | 1 in 5,000 |
| Statistics from St. Bartholomew's Hospital from 1875 to 1890: | | | |
| Chloroform | 19,526 | 13 | 1 in 1,502 |
| Ether | 8,491 | 3 | 1 in 2,830 |
| "Gas and ether" | 12,941 | 1 | 1 in 12,941 |

There are very few reported deaths from nitrous oxide, and considering the many millions of administrations that have taken place, the *rate* of its mortality would probably be one in several hundred thousands.

It is the writer's opinion that the statistics of anæsthesia are particularly unreliable and misleading owing to unreported fatalities, of which there are probably a far greater number than of those reported. Julliard has given particulars of 20 deaths by chloroform that took place within his knowledge, only 3 of which had been published. Waller refers to 3 cases not reported, and mentions one hospital from which 2 chloroform deaths were reported out of 9 that occurred during one year.