closing teeth—and the neck is swollen. In some exceptional cases emprosthotonos or pleurothotonos is observed instead of opisthotonos.

The spasm gradually passes off, the muscles relax, the eyes and pupils become normal, and respiration is resumed. The patient speaks, usually calls for air, desires to be held, and is in dread of impending death. Indeed, consciousness and intellectual activity do not seem to be impaired during the spasms.

After the first convulsion others, similar in character, occur, either spontaneously or in consequence of very slight unexpected excitation. An attempt to move the patient, a slight jarring of the floor or bed, a sudden noise, a slight draught of air, or even a flash of light, is sufficient to provoke a spasm if the patient do not expect it. On the other hand, much more active excitation fails to call forth a spasm if the patient be not taken unawares; and he frequently asks to be rubbed, held down, or moved. When the spasm recurs spontaneously, the patient usually announces its coming some seconds in advance, and asks to be held.

The number of convulsions usually varies from three to ten, but in prolonged cases, whether fatal or non-fatal, the number may be much greater. Their duration is from thirty seconds to five or even fifteen minutes. The intervals vary in duration from forty-five seconds to one hour, or even to one hour and a half; usually they last for from five to fifteen minutes.

In cases terminating in recovery the interval between the spasms increases in length and the convulsions become less active and shorter in duration, and finally cease, leaving the patient in a condition of great muscular fatigue, and with increased reflex irritability. In fatal cases death results from one of two causes: In some cases death is due to asphyxia by fixation of the muscles of respiration during a protracted spasm; in others it is due to exhaustion, and occurs during the non-tetanic period. In most fatal cases death occurs during or after the fourth or fifth tetanic seizure, although cases have occurred in which the patient has succumbed at a later period, and others in which life was extinguished during the third, second, or first convulsion.

Duration.—The rapidity of action of strychnin is modified by the form in which it is taken, whether in solution or in a hard and difficultly soluble pill, and by the length of time which is allowed to elapse before treatment is resorted to.

In 78 cases, in which the time of first appearance of the symptoms was noted, the period was "directly, or very soon," in 20; from three to thirty minutes in 40; from thirty minutes to one hour in 7; from one to two hours in 6; and from two to three hours in 5. The average period of delay is, therefore, within twenty minutes. The extremes are "directly" and three hours. The appearance of strychnin symptoms is delayed when large doses of opiates are taken with it.

The total duration of strychnin poisoning is also short, whether it terminate in death or in recovery. Of 143 fatal cases of which the duration is stated, 77 died within one hour; 32 in from one to two hours; 10 in from two to three hours; and 24 in from three to eighteen hours. In the majority of these cases the entire duration was less than one hour. The extremes were "immediately" (from a dose of one and three-fourths grain, combined with an equal quantity of nux vomica), and eighteen hours (from a dose of three grains), both adult males.

In non-fatal cases recovery is usually rapid, the active symptoms cease within a few hours, and, after cessation of the spasms, the patient may be considered as out of danger, although in exceptional cases great muscular prostration and occasional involuntary muscular contractions continue for some days.

Differential Diagnosis.—The disease bearing the closest resemblance to strychnin poisoning is traumatic tetanus. In poisoning by strychnin the attack is more sudden than in tetanus, and the entire history of the case is compassed within a few hours, in place of lasting for days. The spasms follow each other at shorter intervals, and are of shorter duration, in strychnin poisoning than in tetanus. In the latter, trismus is one of the earliest and most prominent of the characters, while in the former it occurs later, if any succession of symptoms be observable, and may be insignificant as compared with the violent tetanic contraction of the respiratory muscles. During the intervals between the convulsions due to strychnin the muscles are usually relaxed, while in tetanus they remain more or less rigid, particularly those of the lower jaw. The chief points of distinction are in the much more rapid progress of strychnin poisoning, and, in the great majority of cases, in the history of the onset, which, in the poisoning, follows, with very little warning, within two hours or less, the ingestion of some bitter substance, but in tetanus is gradually developed several hours or days after an injury.

Uncertainty concerning the diagnosis between epilepsy and strychnin poisoning can only occur in the very exceptional case of an unknown person dying during a single convulsion. In such an event chemical analysis would decide the question definitely. In other cases the history of the case, the much longer interval between the paroxysms in epilepsy, and the more distinctly tonic character of the spasms in strychnin poisoning, are sufficient to establish the distinction.

In cases of poisoning of pregnant women by strychnin (two such are cited by Wharton and Stillé, pp. 443, 625) the distinctions between the effects of the poison and puerperal convulsions are of importance. The principal diagnostic point is in the fact that in puerperal convulsions the patient is entirely unconscious of what occurs, either during or between the convulsions, while in strychnin poisoning consciousness remains unimpaired, except immediately before death. The detection or non-detection of strychnin in the body would remove all doubts.

Lethal Dose.—The smallest amount of strychnin which has been known to cause the death of an adult is 0.016 gm. (= gr. ¼), which produced violent symptoms in ten minutes in a female, aged thirty-six, and death in one hour and forty-five minutes (*Medical Times and Gazette*, 1854, p. 376). Double this quantity, 0.032 gm. (=gr. ss.), caused death in two cases. In one of these (case of Dr. Warner) a physician took by mistake half a grain of the sulfate, was violently convulsed in five minutes, and died in twenty minutes. Less quantities have produced dangerous poisoning in adults. Christison cites the case of a child of three years which was killed in four hours by 0.004 gm. (= gr. $\frac{1}{16}$).

On the other hand, numerous cases are on record in which much larger doses have been taken without causing death. Thus Campbell (*Lancet*, 1856, ii., 695) relates a case in which a man, aged thirty, took 0.65 gm. (= gr. x.) of strychnin and recovered. Shaw (*American Journal of the Medical Sciences*, 1856, 547) cites the case of an adult female who recovered from the effects of a dose of 0.65 to 0.97 gm. (= gr. x. to xv.). Tschepke (*Deut. Klin.*, 1861, ex "Maschka Handb.," ii., 613) gives a case of a pharmacist who took from 0.48 to 0.72 gm. (= gr. viiss. to xi.) of strychnium nitrate dissolved in about 30 gm.)= fl. ʒ i.) of bitter-almond water, and, after half an hour, having experienced no symptoms, 0.6 gm. = gr. ix.¼) of morphium acetate, also dissolved in bitter-almond water. Subsequently, being still capable of locomotion, he poured chloroform upon his pillow and lay with his face upon it. An hour and a quarter after taking the first dose he suffered violent symptoms of strychnin poisoning, from which he, however, recovered under treatment by emetics and tannin. Wilson (*American Journal of the Medical Sciences*, 1864, N. S., xlviii., 70) cites a case in which the amount taken was 2.6 gm. (= gr. xl.), probably the largest not causing death.

Treatment.—The ends to be aimed at are the removal of any unabsorbed poison from the stomach, if possible, and the prevention or mitigation of the paroxysms. Chloral should be generously administered, followed by inhalations of chloroform sufficient, and sufficiently prolonged, to control the convulsions until the poison shall have been eliminated, as it is with considerable rapidity. In





the exceptional cases in which the patient is seen before the tetanizing action of the poison has been established, the stomach should be washed out as expeditiously as possible with a strong infusion of tea, or a solution of tannin in some form, or water holding powdered charcoal in suspension. Usually stomach lavage must be deferred until the patient has been brought, at least partially, under the influence of the anæsthetic. No reliance is to be placed upon camphor, albumen, opium, aconite, cannabis indica, or tobacco, which have been suggested as so-called physiological antidotes.

Post-mortem Appearances.—There are no peculiarities discoverable, on external or internal examination, which are characteristic of this form of poisoning. Rigor mortis is more rapidly established and continues for a longer period in most cases. According to Wharton and Stillé, rigor mortis was very marked in the body of a woman exhumed two weeks after death (*Medical Jurisprudence*, ii., 445). Taylor ("Poisons," third American edition, 676) states that cadaveric rigidity was well marked in the body of Cook two months after death. Usually the body is relaxed at death and soon stiffens, but in some cases the tetanic spasm merges into rigor mortis. But instances are met with in which cadaveric rigidity has disappeared in from twenty-four to forty-eight hours. In some cases the hands are firmly clenched and the soles arched after the other muscles have become relaxed. Rigidity is of shorter duration in the bodies of those in whom the spasms have been more or less controlled by treatment during life, than in those who have died without medical interference. The surface is usually livid, but not in all cases. Sometimes lividity is confined to the fingers, and in some cases the inner surfaces of the thighs and arms assume a red color.

The internal appearances are still less characteristic. The blood is usually fluid and dark. The vessels of the scalp, the brain and its coverings, and of the spinal cord, as well as the lungs, are in most cases congested. The heart is usually empty and sometimes firmly contracted, the right side being less so than the left, and sometimes distended with dark, fluid blood. The bladder is usually empty, though in some cases it has been found to be nearly full of urine. Occasionally ecchymotic spots or patches of congestion are observed in the stomach.

Analysis.—In cases in which the analysis is not to be limited to a search for strychnin, the systematic method of Dragendorff for the separation of alkaloids and glucosids from organic mixtures should be followed. By this method any strychnin which may be present in the substances examined will be found in the residues of evaporation of the benzene extract from the alkaline aqueous solution.

In all cases it is advisable to resort to Dragendorff's method, even when the history of the case points very directly to strychnin, as any question subsequently arising as to the presence or absence of another alkaloidal or glucosidal poison can then be determined.

In some exceptional chemico-legal cases, and when the physician wishes to determine the presence or absence of strychnin in the urine during the life of the patient, an abridged modification may be used. If the substances to be examined be solid, they should be finely divided and placed in a flask, to which water, rendered distinctly acid with sulfuric acid, is added in sufficient quantity to cover the solid. After agitation, the reaction of the liquid is to be determined, and, if not distinctly acid, it is to be rendered so by the addition of dilute sulfuric acid. The flask and its contents are then to be heated to 40°–50° C. for six or eight hours, after which the liquid is to be filtered off. The extraction should be repeated four or five times with water. The united acid filtrates, which contain any strychnin that may be present in the form of the sulfate, are then evaporated to the consistence of a thin syrup over the water-bath. The residue is mixed with four volumes of strong alcohol, gradually added during stirring, and allowed to macerate twenty-four hours. The cold alcoholic liquid is filtered off, the residue on the filter washed with strong alcohol, and the filtrates and washings evaporated over the water-bath until free of alcohol. The residue, thinned with water if necessary, is transferred to a stoppered cylinder. The solution should not exceed 50 c.c. in bulk, and may be less. About 50 c.c. of benzene (boiling-point not over 85° C.) are then added and the cylinder strongly agitated once every five minutes for about half an hour. The benzene layer is then removed by the separatory funnel and a fresh portion added to the aqueous liquid, which has been returned to the cylinder. This extraction of the acid aqueous liquid is repeated (usually four or five times) until the benzene no longer leaves a residue on evaporation. The purpose of this extraction is to remove pigmentary and other substances, whose presence materially interferes with the reactions. The aqueous liquid is now rendered distinctly alkaline with ammonium hydroxid, and again repeatedly extracted with benzene as described above, but the benzene layers now separated are evaporated in several watch-glasses, and it is to the residues so obtained that the tests for strychnin are to be applied.

If the substance to be examined be a liquid, it should either be evaporated to dryness, the residue extracted with acidulated water, and the filtered aqueous extract treated with benzene, the watery solution being first acid, then alkaline, as above described; or, in the case of a simple aqueous solution, the treatment with benzene may be applied directly, care being had as to the reaction.

In order that the tests may be relied upon, particularly when the alkaloid is present in small amount, as in the case of absorbed strychnin, it is essential that foreign substances be removed as completely as possible. Therefore, if the benzene residue from the alkaline solution be colored, it should be purified by dissolving it in a small quantity of dilute sulfuric acid, agitating with benzene, rendering alkaline, and again extracting with benzene.

Tests.—1. Strychnin crystallizes from an alcoholic solution in small, four-sided, orthorhombic prisms, terminating in four-sided pyramids; sometimes also in small hexagonal plates. Precipitated by ammonia from solutions of its salts, it forms slender, needle-like, four-sided prisms.

2. The taste of strychnin is intensely and persistently bitter, with a faintly metallic after-taste. The bitter taste is still perceptible in a solution containing only one part of strychnin in two hundred thousand of water.

3. Strychnin dissolves in concentrated sulfuric acid, forming a colorless solution of the sulfate. If, now, nascent oxygen be generated in the solution, a peculiar play of colors is produced; at first, and but for an instant, blue (this is sometimes absent), then violet, which gradually changes to red, and then to yellow.

This test, which is most delicate and characteristic, may be applied in a variety of ways.

The sulfuric-acid solution may be placed upon a strip of platinum foil connected with the positive (platinum) pole of a single Grove cell, and a platinum wire, connected with the negative (zinc) pole, brought into contact with the upper surface of the drop of liquid. The nascent oxygen liberated at the foil produces a purple-violet blotch.

The sulfuric-acid solution may be placed in a watch-glass upon a white background, and a minute fragment of some solid substance capable of yielding oxygen by contact with sulfuric acid drawn through it with a stirring rod. The path of the solid is marked by a streak of color passing through the shades above mentioned. Either manganese dioxid, cerium oxid, potassium permanganate, dichromate or ferricyanid, or lead peroxid may be used. Manganese dioxid, potassium permanganate, and cerium oxid are preferable to the other substances mentioned, and each should be used with separate portions of the residue, if there be sufficient. The dichromate acts quite rapidly, the blue color is not produced, and in solutions containing no strychnin only a yellow color is communicated to the liquid. The manganese dioxid acts much more slowly by reason of its less solubility, the blue color is developed, and, in the ab-