still more uncertain. Between the upper end of the spinal cord and the internal capsule the path has not been definitely located. It probably passes up in the posterior half of the medulla and pons, beneath the corpora quadrigemina, through the tegmentum of the crus cerebri, and passes into the internal capsule, where its position has been accurately determined. As may have been inferred from the remarks on the loss of sensation in the fifth nerve with anæsthesia on the same side of the body caused by a lesion in the internal capsule, the sensory path occupies the posterior third of the posterior limb of the capsule. As the path from the fifth nerve joins it in the upper part of the pons, the posterior part of the capsule transmits sensation from the entire opposite half of the body and head, skin, and mucous membranes. Furthermore, the path of special sensibility from the organs of special sense—vision, hearing, taste, and smell—here lie contiguous to the path of cutaneous sensibility. In the case of vision we must remember that there is not a complete decussation of fibres at the optic chiasm; consequently the half of the field of vision of each eye corresponding to the side from which the other sensory impressions come, is represented in the sensory path. This is of diagnostic importance and will be referred to again.

The final distribution of the sensory path in the cortex is also a matter of some doubt. The sensory fibres pass into the white substance of the central hemisphere and go toward the region covered by the parietal bone and to the quadrate lobe and gyrus fornicatus of the mesial surface of the cerebrum. Much discussion has been had and is still going on as to whether the central (motor) area of the cortex is also a sensory area. A destructive lesion in the motor area causing paralysis also causes more or less anæsthesia of the palsied side. The loss of sensation, however, is not co-extensive with the palsy; neither is it permanent nor so persistent. This, with other facts, leads to the opinion that the motor area subserves sensation not directly from projection of the fibres from the path for cutaneous sensibility, but by commissural fibres.

Hemiplegia may exist without any sensory loss or with every degree of it. Hemianæsthesia may exist alone or in connection with every degree of paralysis up to complete hemiplegia. It is unusual for both to exist in a high degree.

Hemianæsthesia may involve all forms of sensibility, or some more than others. In its complete form it involves one vertical half of the body, including mucous membranes. It is always the result of a lesion in the path; for a cortical lesion, to produce hemianæsthesia, would need to involve so much of the cortex that the disturbance of other functions would overshadow the anæsthesia. If the lesion is in the pons, the parts supplied by the fifth nerve escape. Hence the anæsthesia does not involve the face and head. The most frequent location of a lesion causing hemianæsthesia is in the posterior part of the internal capsule. As was said before, a lesion in this locality causes complete hemianæsthesia and involves at the same time the nerves of special sense. This bears a strong resemblance to hysterical hemianæsthesia. In the latter, however, one-sided amblyopia is most likely to occur, while in the former hemianopsia will result; that is, one-half of each field of vision corresponding to the anæsthetic side will be interrupted. When discussing trigeminal anæsthesia I said that the destruction of the tubercle of Rolando causes loss of all forms of sensibility in the distribution of the fifth nerve, and loss of tactile sense in the body and limbs of the side of the lesion and analgesia of the opposite side. The motor disturbances comprise changes in the pupil, narrowing of the palpebral fissure, lessened prominence of the eyeball on the same side, and paresis of the arm and leg on the opposite side.

Cortical lesions can produce hemianæsthesia only when they are very extensive. The special senses may be involved, but instead of hemianopsia there will be loss of sight in the eye on the anæsthetic side.

Hemianæsthesia with hemiplegia and third-nerve palsy of the same side as the lesion is evidence of lesion of the crus.

Tumors in the cerebral hemispheres are likely to cause more or less loss of sensation, in combination with other symptoms, according to what portion of the cerebrum is involved.

Hemianæsthesia involving all forms of sensation may occur in connection with motor disturbance if the tumor is located in the central area of the cortex. Tumors of the parietal region produce disturbance of the muscular sense as their most characteristic symptom, together with hemianæsthesia. Motor disturbances will occur if the tumor encroaches upon the motor area. In the occipital lobes tumors produce hemianæsthesia if they encroach upon the parietal lobes. Disturbances of special sense, particularly sight and hearing, will also occur.

The study of the sensory, as well as the motor disturbances, is of value simply because it enables one to localize the causes of the symptoms. This is more useful from a surgical than from a medical standpoint. For a pathological diagnosis we must rely upon the history of the case, its mode of development, and concurrent conditions. Any destructive lesion involving the sensory path or cortical distribution will cause a greater or less degree of anæsthesia. Among these may be mentioned tumors, gummata, aneurisms, embolism, thrombosis, hemorrhage, and various degenerative and inflammatory processes. Consideration of these will be found under the appropriate heads. *Joseph A. Weitz.*

ANÆSTHESIA, LOCAL (SURGICAL).—Local anæsthesia, or better, local *analgesia*, became possible when the properties of cocaine were discovered by Koller in 1884. Previous to that time it was known that an area of the skin could be benumbed by cold or by depriving it for a time of its blood supply. But the anæsthetic effect of local anæmia could be obtained only in an extremity, while the chilling or even the freezing of the skin by means of a spray of ether had only a limited application. Koller discovered that a strong solution of cocaine, if applied to a mucous membrane for a few minutes, will make it insensitive to pain. By experiments he proved that a solution of cocaine injected into the tissues has the same effect. This discovery opened a wide field for the surgeon, as many trivial operations could now be painlessly and easily performed without the expense, discomfort, and danger attending the use of a general anæsthetic.

Fifteen years' experience with cocaine has fully justified the claims of its discoverer for its analgesic powers. Experience has shown, however, that it is by no means the harmless drug which its early advocates supposed it to be. Medical literature has recorded a long list of accidents from its use, many of them followed by a fatal result; while, far more frequently, alarming symptoms have developed, which fortunately have subsided after prompt action on the part of the surgeon. There is probably no surgeon of experience who has not met with one or more accidents of this character.

The idea uppermost in the mind of those who early employed cocaine to minimize the pain in operations, was to use a solution strong enough to accomplish this end with certainty. Hence solutions containing five per cent., ten per cent., or even twenty per cent. of the drug were swabbed or sprayed upon mucous surfaces or injected into the tissues. The appearance of toxic symptoms in certain patients impressed upon the minds of careful men the necessity for a change in the method of administration in vogue. As a result, some experimenters began to employ weaker and weaker solutions of cocaine, while others hunted through chemical laboratories for some substance less poisonous than cocaine, with equal analgesic powers, and still others attempted to develop the possibilities of analgesia by cold.

A suitable fluid was found in ethyl chloride. For convenience it is put up in tubes having at either end a minute opening closed with a screw cap. If the tube is held in the hand, a portion of its contents is vaporized

and exerts a pressure within the tube. Hence, if the lower cap is removed, a fine jet of fluid is forced out of the tube and may be sprayed upon the skin. In a few moments whitish spots will appear wherever the cold produced by evaporation is sufficiently intense to freeze the water contained in the skin. This method of obtaining analgesia has been employed in France more than elsewhere. It is most serviceable in benumbing the skin previous to inserting a needle for aspiration, or for tapping hydrocele, or in opening an abscess. From the nature of the case it is unsatisfactory in surgical operations requiring dissection of the tissue. The power of ethyl chloride is not sufficiently great to penetrate deeply, and even if it were, the risk of injury would deter the surgeon from keeping a tissue frozen for any length of time. Moreover, the reaction, when the blood again courses through the part, is often an extremely painful one.

Still other surgeons have followed up the effect of local anæmia in reducing sensitiveness. This method is especially applicable to the hand and forearm. They found that if the blood is pressed from the hand and arm, and the tourniquet applied with sufficient force to prevent any fresh blood from entering, sensation is pretty nearly suspended after a lapse of ten or fifteen minutes. This method of operating deserves wider notice than it has received. It has proved a valuable adjunct to a chemically produced analgesia, since the amount of the reagent needed to deaden pain is far less if the circulation of blood is controlled in this manner. The limb is first stripped of its contained blood by the application of Esmarch's bandage from the finger tips to the middle of the upper arm, each turn of the spiral overlapping the turn below by about half an inch. This enables the surgeon to unwind the bandage from the fingers up, and before the turns above the elbow are removed, the tourniquet should be applied, or the upper turns themselves may be left to act as a tourniquet. Attempts have also been made to render bloodless a part of the lower extremity, or an area of the scalp, or of the cheek, etc., by pressure exerted through variously shaped rings. Anæmia in the regions mentioned is more difficult to obtain, and is, on the whole, less satisfactory than that obtained in the extremities, as above described.

The efforts of other investigators to improve chemical analgesia have been very successful. It was early discovered that a solution of cocaine, even though far less concentrated than those originally employed, is still entirely satisfactory. The credit of enforcing this fact upon the medical world is due especially to a French surgeon, Reclus, and a German surgeon, Schleich.

Reclus advocated the use of a one-per-cent. solution of cocaine, or, in certain cases, of a two-per-cent. solution. Solutions of a greater strength he never employs, claiming that they are unnecessary and dangerous. As long ago as 1893 he published a report of two thousand operations performed in complete analgesia brought about by these weak solutions of cocaine. In no instance was there a fatal accident, nor even any bad symptoms.

Schleich performed a great number of experiments to determine exactly how weak a cocaine solution can be without losing its analgesic powers. His experiments led him to several important conclusions. In the first place, they showed that a solution of cocaine as dilute as 1:5,000 is possessed of analgesic power, although the quantity of fluid injected under such circumstances must be far greater than that injected if the solution contains a high percentage of cocaine. The question now raised in his mind was this: Does not the water, by distention of the tissues, reduce the sensitiveness of the nerves, either by pressure upon them or secondarily through a local anæmia? Further experiments showed that this supposition was partially true, and that pure water injected in considerable quantity has the power of reducing the sensitiveness of the parts. The injection of pure water is, however, very painful. He next tried the effects of the injection of normal salt solution, 0.6 per cent. This causes no pain, but its analgesic effect is practically *nil*. A weaker solution of salt, 0.2 per cent., proved more serviceable. The injection of this solution produces little pain and brings about a slight analgesia. Using this, then, as a vehicle, he dissolved cocaine in sufficient quantity to make a solution of one part in a thousand. To this mixture he added a minute quantity of morphine, believing that the analgesic effect of the cocaine was thereby prolonged. Since the injection of large quantities of fluid in an inflamed area causes great pain, Schleich employs under such conditions a somewhat stronger solution of cocaine, so that a less quantity of fluid may be injected. Indeed, he recommends the preparation of solutions of three different strengths, the formulæ for which are as follows:

	Sol. I.	Sol. II.	Sol. III.
Cocaini hydrochlorici	0.2	0.1	0.01
Morphinæ hydrochlorici	0.025	0.025	0.005
Natr. chlorat. sterilisat	0.2	0.2	0.2
Aquæ destill. sterilisat	ad 100.0	100.0	100.0
Adde acid. carbol. (five per cent.)	gtt. 2	gtt. 2	gtt. 2

Solution I. for hyperæsthetic areas (inflammation, suppuration, neuralgia).
Solution II. for moderately hyperæsthetic areas.
Solution III., for extensive operations, to be used alternately with the more concentrated solutions.
For general work Schleich advises the use of Solution II., or the "normal" solution as he calls it.

Schleich also insisted upon a particular method of injection. To render the skin insensitive, the hypodermic needle should be thrust into it nearly parallel to the surface, and not through it. Slow pressure upon the piston will force the fluid into the meshes of the skin, distending them and causing a white wheal to appear. The needle should then be withdrawn and reinserted in the edge of this insensitive wheal, and a second injection made in the same manner as the first. A second wheal is thus produced beyond the first one, in the farther edge of which the needle is again inserted for a third injection. This process is repeated until the benumbed area extends throughout the line of the proposed incision (Fig. 195).

If an abscess is to be opened, or any operation performed which requires cutting beneath the level of the skin, the series of infiltrated areas is made to extend not only across the skin surface, but also in a semicircle beneath the abscess or tumor (Fig. 196). For this purpose a long slim needle is required, and each succeeding injection is made by pushing the point of the needle a little farther under the abscess or tumor. A curved hypodermic needle answers admirably for this purpose. When half

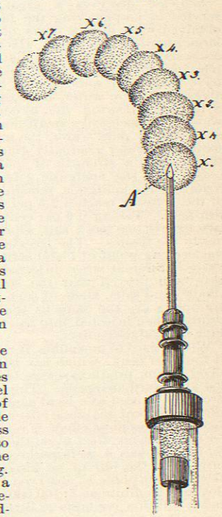

FIG. 195.—Showing Injection Along a Line of Incision in Skin. X, X¹, X², etc., first, second, third, etc., points of injection. After the first puncture, *A*, the needle is always inserted in the edge of the area last anæsthetized. (From Schleich.)

of the required distance has been traversed, the needle is withdrawn and inserted from the other side. In this manner even a deep incision or dissection can be made in perfectly benumbed tissues (Fig. 197).

Injections of every character into skin already tense from contained exudation are extremely painful from the additional stretching of the tissues which they produce. On this account, if the abscess to be opened lies in the skin or so close to it that the skin has become

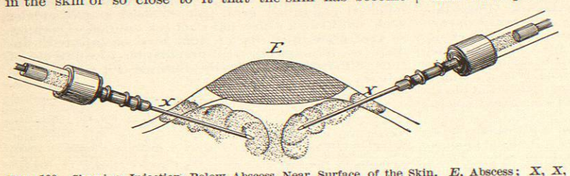

FIG. 196.—Showing Injection Below Abscess Near Surface of the Skin. *E*, Abscess; *X*, *X*, points of injection. (From Schleich.)

tight over it, the pain can be greatly lessened by puncturing the most prominent point of the abscess with a sharp, narrow-bladed knife. A portion of the pus will then flow out, relaxing the tissues so that the whole tract to be incised can be painlessly filled with the cocaine solution. This preliminary puncture can be rendered painless by the ethyl-chloride spray, or a drop of cocaine may be inserted in the skin at this point.

Schleich deserves a great deal of credit for his service in emphasizing the fact that analgesia can be obtained with minute doses of cocaine if injected with large quantities of fluid. His method is known as "anæsthesia by infiltration." Later experiments have emphasized the importance of his discovery, although they have disproved some of his minor theories. The analgesia of pure water, for example, is an analgesia of irritation following the hyperæsthesia caused by the water. If successive small amounts of sodium chloride are added to pure water, the irritation caused by the injection of water gradually diminishes. When the solution attains a strength of 0.55 per cent., the irritation ceases and the analgesic effect also disappears. The irritation and analgesia remain absent until the strength of the solution reaches 2.5 per cent. and then they both reappear. Taking 0.9 per cent. as a mean between these two figures one has a salt solution which is least irritating to the tissues. The freezing point of this solution is the freezing point of blood serum. It is therefore osmotically indifferent when injected into the tissues. It has also been proved that the solutions of various other alkalies and salts, made of such strength that their freezing points are the same as that of blood serum, do not irritate when injected into the tissues, and consequently have no analgesic effect.

With regard to morphine, it may be said that a solution of four per cent., which has the same freezing point as blood serum, produces severe burning and hyperæsthesia and afterward analgesia. This solution is, of course, too strong to be used as a local analgesic. As the solution is diluted its local analgesic effect rapidly diminishes, while the local poisonous effect is retained. A solution of 0.1 per cent. has no effect upon the sensitiveness of the skin, but it produces a well-marked wheal, which itches and burns like the bite of an insect. This local poisonous effect of morphine is observed even if the solution employed is as dilute as 1:100,000 parts of water, although such a solution contains so little morphine that its presence cannot be proved by any chemical test.

Many other substances have been hailed as substitutes for cocaine, but with one exception they are inferior to it, either on account of the local irritation which they cause, or because they do not produce a satisfactory numbness, or because they are even more poisonous than cocaine. Take, for instance, aneson, a watery solution of acetonchloroform, which has a freezing point of 0.18° C. To bring this to the level of the freezing point of blood serum, 0.35° C., requires an addition to the solution of 0.6 per cent. of salt. Even then the injection of aneson is somewhat painful. It produces analgesia lasting several minutes. If diluted still further, the irritation is less, but the analgesic power rapidly diminishes. For practical use it cannot be diluted with more than three parts of an indifferent medium. Such a solution of aneson is equivalent in analgesic power, therefore, to a cocaine solution of 0.02–0.05 per cent.

Comparing the poisonous effects of the two solutions, cocaine is found to be far less dangerous. Whereas 100 cm. of the solution of aneson will render a rabbit unconscious for twenty-four hours, 100 cm. of a 0.05-per-cent. cocaine solution will have hardly any effect upon the rabbit's general condition. Guaiacol, orthoform, holocaine, and eucaine A all irritate or injure the tissues and fall far below cocaine in analgesic value. Tropacocaine stands nearer to it, though it has a slight local irritating effect. But its poisonous properties are less marked than those of cocaine, and its solutions, besides keeping well, may be boiled without loss of analgesic power. For use it should be dissolved in a 0.6–0.8-per-cent. salt solution, to the amount of 0.1–1.0 per cent. Such a solution will be osmotically indifferent and can be used with satisfaction. The advantages of tropacocaine are, however, overshadowed by those of eucaine B.

The best local analgesic thus far discovered is known as eucaine B. Numerous experiments have shown that this substance is less poisonous than cocaine; that its specific irritation is even less than that of cocaine; that its solutions may be kept for a longer time without change, and may be sterilized by boiling without loss of strength. Most important of all, its analgesic power is

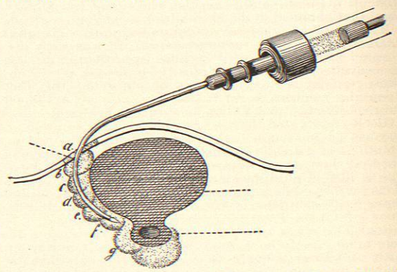

FIG. 197.—Showing Injection Around Tumors with Curved Needle. *G*, Ganglion; *S*, skin; *T*, tendon and sheath; *a*, *b*, *c*, etc., first, second, third, etc., points of injection. (From Schleich.)

equal to that of cocaine, and the analgesia lasts as long. It may indeed be considered the ideal drug of its kind. The solution of eucaine B recommended by Braun—who has done as much as any one to place the subject of local analgesia on a strictly scientific basis—contains 1 part of eucaine B, 8 parts of sodium chloride, and 1,000 parts of water. He has used this mixture in a great number of cases with entire success and with complete absence of toxic symptoms. This solution produces analgesia in a few minutes at any temperature. If, however, the tissue into which it is to be injected is particularly sensitive, for example in the presence of inflammation, temperature irritation may be avoided by warming a solution to the body temperature before injecting it.

The duration of analgesia increases with an increase in the strength of the solution of cocaine or eucaine employed. Thus the analgesia produced by a 0.02-per-cent. solution of cocaine will last six minutes, that of a 0.1-per-cent. solution, fifteen minutes, that of a 1.0-per-cent. solution, twenty-five minutes, while the analgesia of very strong solutions will last from one-half an hour to an hour. These figures, which are of course approximate and not absolute, are about the same for cocaine and eucaine.

A strong solution of cocaine or eucaine will diffuse itself throughout the neighboring tissue, and in a short time exert an analgesic power beyond the immediate area distended by the injection. If the blood supply of the part is cut off or reduced by a bandage or tourniquet, this diffusion will extend even more widely, since the drug will not so quickly be carried away by the flow of blood. With the diluter solutions diffusion beyond the area distended by the fluid scarcely takes place at all, so that it is necessary to inject the fluid wherever the knife is to follow.

In operations upon a finger or toe the eucaine may be injected circularly around the member; in this manner all of the cutaneous nerves will be benumbed, so that an operation upon the distal portion of the finger will produce no pain. This method of anæsthesia, called regional anæsthesia, was first introduced by Oberst.

The hypodermic needle employed for anæsthesia should be of the finest and sharpest. There is no comparison in the amount of pain caused by pushing a coarse, blunt needle into the tough skin and that produced by a sharp needle of the smallest calibre. If this precaution is observed it will never be necessary to freeze the skin before the puncture is made, for the pain caused by the insertion of such a needle is merely that of a slight prick. The first puncture should never be made in an inflamed area if it is possible to avoid it, but in the sound skin close by. The second puncture can be made in the farther edge of the first, and the third in the farther edge of the second, and so on until the inflamed area has been anæsthetized, absolutely without pain (Fig. 195).

What operations are suitable for local anæsthesia must be determined by the individual surgeon. Laparotomies can be performed under local analgesia, or a thigh can be amputated absolutely without pain by this means. Such operations have sometimes been performed with the use of cocaine, but it does not follow that because they are possible, they ought, therefore, to be advised. Other considerations must come in, and the necessity for haste, the advantages or disadvantages of allowing the patient to retain consciousness, the necessity for manipulation of the surrounding organs, the importance of muscular relaxation, and other points will have immediate bearing upon the choice of an anæsthetic. There are doubtless instances in which the general condition of the patient will incline the surgeon to the performance of major operations with the help of a local anæsthetic, which under other circumstances he would always perform with a general anæsthetic. It was at one time supposed that broncho-pneumonia, which sometimes kills a patient upon whom a severe operation has been performed while under the influence of ether or chloroform, might be avoided by the use of cocaine. Unfortunately, this has not proved to be the case, as broncho-pneumonia may also follow a severe operation upon an enfeebled patient, even though no general anæsthetic is given.

Decision will rest no less upon the character of the patient to be operated upon, than upon the character of the operation to be performed. Very young children, and nervous persons to whom the thought of the knife is fully as distressing as the pain of its cutting, will be saved a great deal of shock if given a general anæsthetic; and the surgeon under such circumstances will be able to give his undivided attention to the work in hand, which will not be the case if pain is dulled by eucaine or cocaine. Many persons, on the other hand, have a dread of suspended consciousness, which will lead them to suffer a considerable amount of pain rather than to submit to etherization. The practical plan, in all doubtful cases, is to prepare the patient for a general anæsthetic, and to have it ready. Then the patient will receive the local injections in the comforting confidence that if they fail to relieve him of pain, he can drown his woes in the ether cone. It has been the experience of the writer and others, that under these circumstances the general anæsthetic is rarely asked for.

There are some lesser operations, however, which ought never to be performed with the help of a local anæsthetic—such operations as the dissection of an axilla whose glands are the seat of cancerous deposits, and in general any operation the success of which depends upon the recognition of the line between diseased and healthy tissue. The local anæsthetic, even though it be an osmotically perfect solution, causes an œdema which makes it more difficult for the surgeon to tell how far the disease extends. Under these circumstances a general anæsthetic should always be given.

The only method of producing local analgesia by drugs thus far spoken of is the method by injection. The application of cocaine to the skin will not produce analgesia, unless the drug is driven into it by means of a strong galvanic current—the method of cataphoresis, as it is called. But mucous membranes are capable of absorbing a sufficient amount of cocaine to render them insensitive. For this purpose the solution employed must be far stronger than that employed in the infiltration method, though there is no doubt that unnecessarily strong solutions have been used upon the mucous membranes. Several fatal cases have been reported from the injudicious use of cocaine upon mucous membranes. One drachm of a four-per-cent. solution, injected into the urethra, has caused the death of an adult inside of four minutes, while half of that amount has killed a child within three days from the time of injection. Smaller quantities have caused alarming though not fatal symptoms. In every case in which cocaine or any other drug is injected the surgeon ought to know exactly how much he is administering. The minimum fatal dose of cocaine for an adult is certainly not more than one-third of a grain. This amount is contained in seventeen minims of a two-per-cent. solution, or in eight minims of a four-per-cent. solution. The injection into the urethra of a twenty-per-cent. solution is absolutely unwarrantable, while the practice of anæsthetizing the nasal cavities by means of a spray is also to be condemned. Instead, the drug should be applied on a swab, and then the operator will know how much of the drug he is applying.

The sensibility of a considerable portion of the body can be reduced or even entirely suspended by the injection of a small amount of cocaine by a lumbar puncture into the spinal canal. Fifteen minims of a one-per-cent solution injected in this manner have sufficed to render insensitive to pain, for a half-hour or more, the whole lower half of the body of an adult. Rather extensive operations have been performed in this manner, but they might have been done equally well, apparently, by means of injections made locally, while the lumbar punctures were followed in almost every instance by headaches and pain in the back and legs for a day or longer, and in some instances by attacks of vomiting for several hours. These unpleasant symptoms were equally marked in the one instance in which tropacocaine was employed instead of cocaine, so that analgesia by lumbar injections has not yet passed beyond the stage of scientific experimentation, and it is doubtful if it will do so.

In spite of all that has been written in favor of the use of dilute solutions of cocaine, or, better still, the substitution of eucaine B for cocaine, many dangerously strong solutions of cocaine will still be employed. It is not, therefore, out of place to mention the toxic symptoms of the drug, and the appropriate treatment for them. The various symptoms mentioned are pallor, profuse perspiration, frequent, feeble, irregular, or intermittent pulse, unconsciousness, dizziness, nausea, blindness, deafness,

muscular rigidity, lividity, convulsive or suspended respiration, and paralysis. In the slighter cases of poisoning, the symptoms are over in a few hours. Among the antidotes recommended are amyl nitrite, nitroglycerin, ammonia, digitalis, whiskey, atropine, and morphine, but above all it is important to place the patient in a horizontal position, to loosen his clothing, and to perform artificial respiration if necessary. Even though attempts at resuscitation are successful, it is not safe to leave a patient for some time afterward, as a second or third collapse may occur.

Another evil connected with the use of cocaine is the danger that it may lead to the cocaine habit. This danger is most likely to follow the use of cocaine in the nose. On account of its contractile power, the relief which it affords in inflammatory conditions, such as acute coryza or hay fever, is so prompt and delightful that the desire to repeat the application soon becomes very strong. Even more than morphine the drug soon has a terrible grasp upon the unfortunate sufferer, which few men have ever been able to shake off. Many physicians have fallen a prey to cocaine. Under such circumstances a strong word against its careless use is in place here, although the habit has not usually followed its administration for local analgesia.

Edward Milton Foote.

ANÆSTHETICS.—Agents capable of producing privation of sensation, or anæsthesia (from *a*, privative, and *αισθάνομαι*, I feel), when inhaled or applied locally, have been termed anæsthetics. While the word "anæsthesia" more properly indicates the *condition* of want of sensibility or feeling, it has also been applied and is commonly used to denote the *state* produced by the administration of the general anæsthetics, of which want of feeling is but one of many factors. The word "narcosis" (from *νάρκωσις* or *νάρκη*, numbness or paralysis) is also much employed to signify the *state* of the anæsthetized individual, and will be so used in this article. Agents which act upon the whole organism by their absorption into the blood are called *general* anæsthetics. Those which act only upon the part to which they are applied are called *local* anæsthetics.

Ancient History.—To seek relief from pain is instinctive and the practice of measures for this purpose is undoubtedly of as great antiquity as man's existence. Efforts to obtain freedom from suffering during surgical and other painful procedures are recorded throughout ancient history, and the works of the earliest medical writers contain numerous references to methods in vogue in their times for the mitigation or prevention of pain, through the exhibition of drugs by internal administration, by inhalation, and by local application.

Mandragora, cannabis indica, and opium are the agents that were most commonly used for this purpose, although belladonna, hyoscyamus, hemlock, and others are frequently mentioned in this connection. Mandragora (atropa mandragora) seems to have been the earliest and most favored narcotizing agent of the ancients, and must have been in general use in the times of Dioscorides, Pliny, and Apuleius, for in their writings its action and uses are freely discussed.

Dioscorides mentions three different preparations of mandragora in these terms: 1. "Some persons boil the root in wine down to a third part and preserve the decoction, of which they administer a cyathus [ʒ iss.+] in want of sleep and severe pains of any part, and also before operations with the knife or the actual cautery, that they may not be felt." 2. "A wine is prepared from the bark of the root without boiling, and three pounds of it are put into a cadus [about eighteen gallons] of sweet wine, and three cyathi of this are given to those who require to be cut or cauterized, when, being thrown into a deep sleep, they do not feel any pain." 3. Of another kind of mandragora called "marion" he states: "They relate that a drachm of it being taken as a draught, or eaten in a cake or other food, causes infatuations, and takes away the use of the reason. The person sleeps without sense, in the attitude in which he ate it, for three or four hours afterward. Medical men also use it when they have to resort to cutting or burning."

Pliny, writing of the juice of the leaves of mandragora, states that "it has a soporific power on the faculties of those who drink it; . . . the dose is half a cyathus; . . . some persons even die from a considerable draught; . . . it is taken against serpents, and before cuttings and puncturings, lest they be felt."

Apuleius has written of mandragora: "If any one eat it he will immediately die, unless he be treated with butter and honey and vomit quickly. Further, if any one is to have a limb mutilated, burnt, or sawn, he may drink half an ounce with wine, and whilst he sleeps the member may be cut off without any pain or sense."

Cannabis indica, which is probably the "hasheesh" or "bhang" of the East, the Ma yo of the Chinese, and the "nepenthe" of Homer, was employed by the Scythians, as related by Herodotus, for the production of intoxication. In the East it has long been used for this purpose and for the relief of pain, particularly in the case of criminals about to undergo torture. An example of the use of cannabis indica to prevent the pain of surgery occurs in a biographical sketch of Hoa tho, a Chinese practitioner, of whom it is stated that "if the malady was situated in parts on which the needle, the moxa, or liquid medicines could not act, for example in the bones, in the medulla of the bones, in the stomach, or the intestines, he gave the patient a preparation of hemp, and, at the end of some instants, he became as insensible as if he had been drunk or deprived of life. Then, according to the case, he made openings and incisions, performed amputations, and removed the cause of the malady; he then brought together the tissues with points of suture and applied liniments. After a certain number of days the patient found himself re-established without having experienced the slightest pain during the operation."

Cannabis indica was almost invariably administered by the inhalation of its fumes when burnt, and Pliny, in recording the properties of the juice of mandragora leaves, states: "For these purposes [against serpents and before cuttings and puncturings, lest they be felt] it is sufficient for some persons to have sound sleep from the smell [of the medicine]."

In the thirteenth century Theodoric produced insensibility to the pain of operations by means of narcotic inhalations from a "sleeping ball" or "spongia somnifera," used and described by his teacher, Dominus Hugo of Lucca, and thus made: "Take of opium and the juice of unripe mulberry, of hyoscyamus, of the juice of the hemlock, of the juice of the leaves of the mandragora, of the juice of the woody ivy, of the juice of the forest mulberry, of the seeds of lettuce, of the seed of the burdock which has large round apples, and of the water hemlock, each one ounce; mix the whole of them together in a brazen vessel, and then in it place a new sponge, and let the whole boil as long as the sun lasts on the dog-days until the sponge consumes it all and it is boiled away in it (the sponge). As oft as there shall be need of it, place this sponge in hot water for an hour and let it be applied to the nostrils of him who is to be operated on till he has fallen asleep: and so let the surgery be performed. This being finished, in order to awaken him, apply another sponge, dipped in vinegar, frequently to the nose, or let the juice of the roots of fenugreek be squirted into his nostrils. Presently he awakens."

Although the efficiency of this plan has been doubted, it is recorded that in 1832 M. Dauriol in France, following these directions, operated painlessly in five cases, which he reported. Greek and Roman authors have described the effects of mandrake in preventing the pain of operations, but it seems to have been little used by them on account of its fatal effects; in fact, it is probable that all of the foregoing means of rendering surgery painless were dangerous.

Pliny and Dioscorides describe the local benumbing

effects produced by the application of pulverized marble (memphitis) with vinegar, stating that it will "stupefy parts to be cut or cauterized, for it so paralyzes the part that it feels no pain." Numerous other methods of producing insensibility to the pain of surgical operations are recorded, notably compression of the vessels of the neck as practised by the ancient Assyrians during circumcision, which probably acted by producing the unconsciousness of cerebral anæmia (as also brought about by excessive and rapid venesection for similar purposes); compression of the nerves supplying the part operated upon, as carried out with some success in 1784 by James Moore, an English surgeon. Hypnotism, which "was known to the Indians, Egyptians, and Persians at a very remote period," has been extensively tried as a means of rendering patients insensible to the pain of operations. Cloquet removed a breast painlessly from a hypnotized patient in 1829, and at a later period Esdaile in India performed several hundred operations upon patients, chiefly Hindoos, in the hypnotic state. Elliotson and Braid advocated the method in England, and Liston employed it with some success. Simpson investigated the subject thoroughly and made many very successful experiments with it, but abandoned it as impracticable. The practice of hypnotism for the production of anæsthesia has never come into general use and probably never will, from the fact that only a very small percentage of persons can be satisfactorily put into this state, and in these, repeated attempts are often necessary before a sufficiently deep sleep can be induced so that the subject will be insensible to pain. Furthermore, the condition of the patient during the operation is often far from satisfactory on account of "convulsive movements of the limbs, corrugation of the brows, and even loud cries and sobs," which occur in many cases.

For a long period before the introduction of the anæsthetics of to-day, opium and alcohol were the chief agents employed to lessen operative pain; but the results were far from satisfactory, and M. Velpeau in 1839 wrote: "To escape pain in surgical operations is a chimera which we are not permitted to look for in our day. A cutting instrument and pain, in operative medicine, are two words which never present themselves the one without the other, in the mind of patients, and it is necessary for us as surgeons to admit their association."

Modern History.—The incidents leading up to the discovery of the anæsthetic properties of nitrous oxide, ether, and chloroform, and the introduction of these agents into surgical practice, form one of the most interesting chapters in medical history. In 1799 Humphrey Davy published on account of his extensive researches concerning nitrous oxide, and stated that "as nitrous oxide, in its extensive operation, appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place." Even before this time ether was used by inhalation for the relief of affections of the chest and was known to relieve pain and promote sleep. In 1818 Faraday is said to have pointed out that the inhalation of ether vapor produced effects similar to those of nitrous oxide. The intoxication resulting from the breathing of diluted vapors of these agents became very well known, and was commonly practised as a means of pleasure and amusement. During an exhibition of this kind in Hartford, Conn., on December 10, 1844, Horace Wells, a dentist of that place, took note of the fact that while under the influence of "laughing gas" a Mr. Cooley sustained an injury of the leg without the least evidence of pain. The following day Wells inhaled the gas and had a large molar tooth extracted. As he recovered consciousness he stated that it had not hurt him "more than the prick of a pin," and that it would create "a new era in tooth-pulling," a prediction that has been fully realized, although Wells did not live to see it. After his own experience he immediately tried the gas in his practice with great, though not invariable, success. In a public demonstration of its action at the Harvard Medical School a short time later, the patient—owing no doubt to the imperfect method of administration employed—gave unmistakable signs of pain upon the extraction of a tooth. Wells was hissed and ridiculed by the students present; and although discouraged and believing the gas to be uncertain in its action, he continued to use it in his practice for a number of years.

Wells died in 1848, and nitrous oxide was generally discredited till 1867, when Colton reported twenty thousand successful administrations. After this it rapidly assumed its present status as an anæsthetic. This demonstration of the action of nitrous oxide is not generally looked upon as the discovery of anæsthesia, though in Hartford a monument erected to Wells is thus inscribed:

Horace Wells, who discovered Anæsthesia,
December 10, 1844.

William T. G. Morton, a dentist of Boston and a partner of Wells in 1842–43, devised an improvement in making artificial teeth which necessitated the extraction of all old roots, over which the plates were made and worn at that time. Great difficulty was experienced in inducing patients to submit to this operation on account of the pain, and Morton sought diligently for better methods of preventing it than by the administration of enormous doses of alcohol or opium, commonly used at this time for such purposes. Familiar with the action of nitrous oxide, and knowing the similar effects of ether, he was led to experiment with the latter upon himself and on animals. After succeeding in completely etherizing a dog, he rendered himself unconscious for over seven minutes by inhaling ether from a handkerchief. This occurred on September 30, 1846, and the same evening he administered it to a patient for tooth extraction with perfect success. Within a week he requested Dr. John Collins Warren, a prominent surgeon of Boston, to permit him to administer the agent for him in a surgical operation, and this was done at the Massachusetts General Hospital on October 16, 1846, with such success that Dr. Warren, a very conservative man, exclaimed to the large audience of medical men and students present: "Gentlemen, this is no humbug!"

This was the first public demonstration of the action of ether as an anæsthetic, and although numerous claims of priority have been made, Morton is generally credited with giving the inestimable gift of anæsthesia to the world. The knowledge of this discovery and its use in dentistry and surgery spread with great rapidity. Ether was first administered in England on December 19, 1846; a few days later it was employed in France, and in a remarkably short time its use became almost universal. On January 19, 1847, Simpson first employed ether during labor for forceps delivery, and a few days later to relieve the pain of ordinary labor. He immediately called the attention of the profession to the subject, and notwithstanding widespread and outspoken objections to anæsthetics in these cases, and even in surgery, upon the religious opinion that pain under these circumstances was the will of God and should therefore be borne, their use has become almost a routine practice the world over.

The success of ether as an anæsthetic incited a large amount of experimentation with almost every substance, in the hope of discovering a better agent for this purpose, and on November 4, 1847, the anæsthetic property of chloroform was discovered by Dr. James Y. Simpson, who, with his assistants Dr. George Keith and Dr. Matthews Duncan, inhaled it from tumblers and were all rendered unconscious thereby. On the 10th of the same month Simpson read a paper on chloroform before the Medico-Chirurgical Society of Edinburgh, and on the 15th published a pamphlet on the subject, reporting about fifty successful administrations. The apparent advantages of chloroform over ether caused it largely to replace the latter throughout the world, with the notable exception of the northeastern part of the United States, where faith in ether has never been shaken and chloro-