



TUBE WELL, or **DRIVEN WELL**, a device for obtaining water from the soil, consisting of an iron pipe of small diameter, pointed at the lower end, and driven vertically down into the earth usually by means similar to those used in driving oil wells, until it pierces a water-bearing stratum. The tube is provided with a number of lateral perforations near its lower end, through which the water can enter it. In some cases the water exists in the soil under a pressure sufficient to cause it to flow up through the tube and out at the top; but more commonly a pump must be applied at the upper end, to draw the water up to the surface. When the well is to be driven to a depth greater than one length of pipe, the tubing is usually constructed in sections, which are united by means of screw connections; new sections being added at the upper end as the sinking of the well proceeds.

TUBER, a shortened, thickened, fleshy, subterranean stem in which the leaves appear as scales with axillary dormant buds, collectively called "eyes" in the potato, and Jerusalem artichoke, which are good examples. Internally they contain starch as a principal component. Their office is to act as reservoirs of food and to propagate the species when favorable conditions present. Plants which bear tubers are all perennials.

TUBERACEÆ. See FUNGI.

TUBERCULIN, a culture used to test for the presence of the disease tuberculosis in cattle. Prepared as follows: The attenuated cultures of tubercle bacilli or germs are allowed to grow in broth containing glycerine. After growing for several weeks, the bacilli produce certain toxic or poisonous substances which are soluble in and hence dissolved in the broth. The toxic solution is filtered from the bacilli and becomes the solution tuberculin. The process of manufacture has been subject to much variation. When injected in small quantity into a healthy animal it produces no effect, but if the animal has the disease tuberculosis it causes a decided rise in bodily temperature and hence can be used as a test for that disease. It was originally introduced by Professor Koch of Berlin, and hailed as a cure for consumption, on the principle of vaccination for hydrophobia. It proved ineffective, but is by some deemed useful as a test. Consult Cochrane and Sprawson, 'Guide to the Use of Tuberculin' (1915).

TUBERCULOSIS, an infectious, communicable disease caused by the bacillus of tuberculosis. The bacillus induces the formation of little nodules called tubercles. These tubercles may grow in size through the continued action of the organisms; they may soften, break down and be expelled, leaving behind an ulcer or a cavity; they may become hard by a process of sclerosis; or they may calcify. In addition to the local manifestations the disease produces general symptoms like elevation of the body temperature, increased pulse-rate and loss of weight. It is popularly known under a variety of other names as consumption, phthisis, decline, debility, hectic fever and when localized in a special part or tissue, as Pott's disease or hunchback, scrofula, hip-joint disease, white swelling (tuberculosis

of elbow) and lupus (tuberculosis of skin). Contrary to prevalent lay opinion, when properly treated, it is a very curable affection.

Distribution of the Disease, Geographical.—Tuberculosis is the most universal of all diseases. It is found in every part of the world, and has been known from the beginning of history. It was accurately described by Hippocrates (460 B.C.), and by Galen (200 A.D.). It is most prevalent, however, in large cities and especially in overcrowded districts.

Distribution According to Race.—No race is exempt, but some races appear less resistant than others. Indians, when brought into civilization, prove especially susceptible. Among the other races in this country the negroes seem to be the most susceptible with next in order the Irish, while Jews stand at the end of the list. In the general mortality about one-tenth and in the mortality between the ages of 15 and 60 about one-fourth of all deaths are due to it. The number of clinical cases in a community is about 10 times the number of deaths in a year (Rosenau). Eighty per cent of these manifest it in the lungs.

Distribution Among Animals.—Most animals are more or less susceptible. Among domestic animals it is found most frequently in cattle and swine, though sheep and horses are not exempt. Dogs and cats manifest it rarely. It is also found in birds (fowl) and fish. Wild animals in their native haunts seem less susceptible, yet in domestication it is the most common cause of death. Rabbits, guinea-pigs, rats and mice may acquire it. Guinea-pigs are especially susceptible to experimental inoculation and are, therefore, commonly used for this purpose. Though frequent in adult cattle, it is infrequent in calves (Nocard), showing that direct heredity plays no part.

Etiology (Causation).—The actual cause of the disease is the tubercle-bacillus described by Robert Koch in 1882. This is a minute vegetable non-motile organism in the shape of a rod or lead-pencil, measuring about three microns ($\frac{3}{1000}$ of an inch) in length, and about four to six times longer than broad. It is visible only under the higher powers of the microscope, a $\frac{1}{2}$ oil-immersion lens being usually used to study it. Its principal characteristic is its behavior toward aniline dyes. It requires the strongest dyes to stain it, but when stained it holds the dye so tenaciously that exposure even to strong mineral acids for a reasonable time fails to decolorize it. This characteristic furnishes the most ready means for its recognition. It is quite parasitic in nature, growing on but few artificial media, namely, blood-serum, glycerine-agar, bouillon or potato, best on the first. It grows only at the body temperature (37° C.). It is slow in growth, and becomes apparent only from 5 to 14 days after inoculation of the medium. Exposure moist to a temperature of 60° C. for 15 minutes, or boiling, kills it, though freezing has no effect on it. It is killed by direct sunlight within a variable period of time (from 15 minutes on), depending on the season and the character of the medium containing the organism; by diffuse sunlight near a window in a week or two. In growing (either parasitically or without the body) the organism elaborates a chemical product highly poisonous to most animals. It

is this poison circulating in the blood which produces the general symptoms of the disease, such as fever, increased heartbeat, emaciation, etc. Tubercle-bacilli found in different animals differ in their characteristics. The human, bovine, avian and fish varieties have been differentiated. One of the principal points to be noted is the slow propagation of the organisms with the consequent slow development of the disease. The actual infection usually precedes the manifestation of the disease by scarcely ever less than two and frequently as many as 20 years.

Predisposing Causes.—Though the bacillus of tuberculosis is the actual cause of the disease whenever it occurs, other factors require consideration. As wheat will not grow on every soil, so the tubercle-bacillus will not grow in every individual. In fact it would appear that the majority of human beings are quite insusceptible, and that as a rule an overwhelming dose of the organisms repeated frequently for some time is necessary to overcome the resistance. All the conditions necessary to produce susceptibility are unknown, yet it is empirically true (and could be with reason supposed) that any circumstance which tends to lower the general vital resistance decreases the resistance to tuberculosis. Therefore, defective and insufficient food, over-work, worry, chronic alcoholism, surroundings like a damp, dark, overcrowded dwelling, persistent irritation of a somewhat naturally susceptible part of the body, as irritation of the lungs by the constant inhalation of dust (mine-workers, stone-cutters, etc.), previous severe disease like typhoid fever, etc., all tend to increase the susceptibility.

It was thought in the past that the most common cause active in the production of susceptibility was heredity, because the disease manifests itself more commonly in the children of the tuberculous than of the non-tuberculous. Recognizing the communicability of the disease, however, the closeness of the contact after birth easily accounts for this, without it proving them more susceptible. In fact, a strong argument can be deduced to the contrary, namely, that the children of tuberculous parents are less susceptible. Granting the communicability, it is not a surprise that children who are kissed and fondled for years by tuberculous mothers contract it, but it is a surprise if any escape; and if they were more susceptible we would expect them to contract it in such a virulent form that no child of a tuberculous mother would ever reach adult age. The fact is, however, that the majority of children of tuberculous parents never manifest the disease and the ones who do usually manifest it in a very chronic fashion and only after the age of 15. In other words, though these children live in an atmosphere impregnated with the germs, the majority fail to contract it and the remainder resist it for years.

Flick's paper on tuberculosis as a house-disease goes to prove its communicability. He investigated all the houses of the largest, oldest and most thickly populated ward in Philadelphia, and found that the deaths from tuberculosis in that ward were disproportionately large in certain houses. In short, he demonstrated case after case of apparently healthy families moving into a house previously oc-

cupied by a tuberculous person with the result that one or more members died of the disease.

Modes of Infection.—There are four possible modes of infection, namely, inoculation, heredity, inhalation and ingestion.

Inoculation.—Villemin's work, supplemented by that of Cohnheim and Salamonsen, absolutely established the fact that the disease was inoculable. Inoculation is, however, quite rare as a method of general infection in human beings, and its occurrence is practically limited to special occupations. Inoculation with the production of a strictly limited local lesion is reasonably common on the hands of physicians who do anatomical or post-mortem work (the post-mortem wart, the *leichen-tubercle* of the Germans), of butchers, tanners, etc. Local tubercles have also been produced by piercing the ears for earrings, by tattooing and by washing the clothes of a tuberculous patient. Both local and generalized tuberculosis have been reported as a result of the rite of circumcision, the last step in which is the sucking of the wound.

Heredity.—Up to the time of Villemin this was the generally accepted mode of acquiring the disease, though here and there down the centuries from the time of Galen some one has stood out against it in favor of contagion. Hereditary transmission has been experimentally proven on the lower animals (Gärtner), and occasionally demonstrated in human beings by the finding of tuberculous lesions in the fœtus. These proofs occur so rarely, however, that the ordinary view of practically all cases being examples of contagion, is fully warranted.

Inhalation.—The common belief at the present day is that the majority of cases of tuberculosis are the result of inhalation of the germs. The contagiousness of the disease being proven, and the infectious bacilli being found in the matter given off from a tuberculous ulcer (therefore, in the sputum in tuberculosis of the lungs), it is readily understood how people living with a consumptive may be more or less constantly inhaling the contagion. Nuttall's estimate of the number of bacilli thrown off in the expectoration daily could only make one wonder how anybody escapes the disease, were it not that they are so easily and quickly devitalized. In a case where the patient expectorated about four ounces daily, Nuttall estimated the number of bacilli to be from one and a half to four billions in the 24 hours. Experiments on animals with the dust of rooms occupied by tuberculous patients have usually proven positive (Cornet). The arguments for inhalation as the most common mode of infection are: (1) the very great frequency of tuberculosis of the lungs; (2) the frequency with which all persons are exposed to this form of contagion.

Ingestion.—For years it was thought that tuberculosis of the lungs was the result of inhalation of the germs, and abdominal tuberculosis the result of ingestion with food or otherwise. The argument favoring this view appeared plain; namely, that primary mesenteric gland tuberculosis is almost limited to children, especially the bottle-fed. Living as they do entirely on cows' milk, and considering the susceptibility of horned cattle to tuberculosis, the inference seemed so justified that scarcely any

exception was taken to it. In addition, adults who live as a rule on cooked food scarcely ever show mesenteric gland tuberculosis as a primary infection, but practically always tuberculosis of the lungs, which would readily seem to be the result of contact with the disease in their occupation, sleeping-rooms, etc. This plain view of the matter has, however, undergone a change. The majority of clinicians and pathologists of our day believe that children manifest the mesenteric form more frequently simply because these glands are more susceptible at that age, and adults the pulmonary form for an analogous reason. For several years at the end of the 19th century considerable was written to prove that practically all cases of tuberculosis were the result of ingestion of the germs. It was contended that even in tuberculosis of the lungs the germs entered through the digestive tract, passed into the chyle-vessels with the fat, were carried through the thoracic duct to the heart and took up lodging in the lung on account of its non-resistive power. The experiments about this time demonstrating the infectivity of cows' milk became so numerous (Gerlach, Bang, Bollinger, Ernst) that the question of the digestive tract as a probably common route (if not actually the most common) seemed practically settled. At the British congress on tuberculosis in 1901, however, Koch threw a shell which scattered scientific physicians and left them in two hostile camps. Coming from any one else the opinion (for it was scarcely more than an opinion, being based on a small number of experiments) would have been scoffed at, but coming with Koch's authority it could not fail to arouse interest and even advocates. Koch affirmed that the difference between the bovine tubercle-bacillus (that is, the bacillus causing disease in cattle) and the human tubercle-bacillus was such that one was not contagious to the other species, or was so slightly contagious that the number of cases of tuberculosis thus produced might be left out of consideration without impairing statistics. During the past 18 years the efforts to disprove Koch's statement have been numerous, but the question is not yet absolutely settled. Our investigations are conclusive enough, however, to lead us to believe that about 5 per cent of the cases in human beings are due to the bovine bacillus. Practically all of these are in the lymphatic glands of children, or in other extra pulmonary locations; the number in the lungs of adults is negligible.

Primary and Secondary Infection.—The belief is gradually gaining ground that the ordinary manifest tuberculosis of the lungs is a result not of primary but of secondary infection. Inoculation experiments on animals have always shown primary inoculation to produce tuberculosis of the nearest lymphatic glands with no lesion at the site of inoculation, and secondary inoculation to produce no lesion of the lymphatic glands with definite tuberculosis at the site of inoculation. It would appear, therefore, that pulmonary tuberculosis is the result of secondary rather than primary infection and occurs in one of the following ways: The individual ingests tubercle bacilli, which pass through the intestinal wall without producing a lesion, but cause tuberculosis of the mesenteric, and later the bronchial glands.

The disease of the bronchial glands produces stasis of the lymphatic circulation in the lung, with a consequent retrograde flow of lymph, which carries the tubercle bacilli from the glands to the lung tissue. Or after the lymphatic glands have become involved an entirely new infection by inhalation or ingestion produces the pulmonary manifestation. A number of investigators (prominent among them Bushnell) believe that the primary infection practically always occurs in childhood and that adult infection is extremely rare.

Pathology.—When the tubercle bacilli are deposited in a tissue they proceed to multiply. Like other plants in growth, they take from their surroundings the chemical elements necessary. The living cells from which this material is taken die. In addition, the growing bacilli throw off waste products containing a poison (toxin) which kills other cells. We soon, therefore, have the tubercle bacilli in a mass of dead débris. A reaction now occurs on the part of the healthy tissue to prevent extension—the cells of the part multiply, and white blood cells wander in from the blood for the purpose of consuming the organisms. It is this mass of bacilli, débris and new cells which constitutes the tubercle described first by Baillie in 1794, and which is the specific lesion of the disease no matter in what organ it occurs. The débris looks like a soft cheese, and is called caseous material or caseation. The new cells are called epithelioid. Usually a tubercle also shows what we call a giant cell, a cell three to eight times larger than the epithelioid.

The question of the cure of the tubercle seems to depend on whether the epithelioid cells or the tubercle-bacilli obtain the upper hand. If the epithelioid cells are manufactured more rapidly than the tubercle-bacilli destroy them they form a dense wall about the tubercle-bacilli, elongate, become fully formed fibrous connective-tissue cells, thus shutting the bacilli up in a capsule, and the bacilli die, while the caseous material calcifies or is absorbed and replaced by scar-tissue or fibrous tissue. When the amount of fibrous tissue in the lung is large we speak of fibrosis of the lung. If, however, the bacilli are victorious the tubercle may grow larger and, coming in contact with other tubercles, form what is known as a conglomerate tubercle, and so continue until even a whole organ is involved. Again, the caseation may advance so rapidly, especially in the lung, that there is never any sharp demarcation between healthy and diseased tissue. This is generally called diffuse tuberculosis, and in the lungs is known as caseous or tuberculous pneumonia.

Finally, as the tubercle advances, other micro-organisms (particularly streptococci or staphylococci) may gain entrance to the caseous material and break it up. If now the tubercle, in growing, reaches a surface its liquid contents may be expelled, leaving behind an ulcer or a cavity. This happens most frequently in the lungs, and the resultant cavity may be of any size from a pea to that of a whole lobe of the lung.

The cavity is usually within the lung, or if at the margin, is limited by the pleura, which thickens about it. Sometimes, however, it breaks through the pleura, allowing pus into the

pleural cavity, which is called pyothorax or empyema; occasionally both pus and air are admitted producing pyopneumothorax.

When newly formed, tubercles appear to the naked eye as grayish-white or yellowish-white specks about the size of a millet seed, hence the name miliary tubercle. When two or more of these fuse, it is called a conglomerate tubercle. Usually the disease, especially in the lungs, progresses by a small number of tubercles localized in one area running together to form conglomerate tubercles and these again to form a larger mass which we call tuberculous infiltration. Sometimes in non-resisting cases miliary tubercles develop rapidly all through the lung and rarely in many other organs and the individual dies before they become conglomerate. This condition is described as miliary tuberculosis. In growth tubercles destroy the tissue which they replace and even when cure results, they only change to masses of scar tissue; the original tissue never returns.

Lymph-Gland Tuberculosis.—Children are most frequently the victims, and the bronchial, cervical and mesenteric are the glands of predilection. Tuberculosis of the cervical lymph-glands is popularly called scrofula. It is treated in a similar way to chronic tuberculosis of the lungs by rest, fresh air and nourishment, or by the X-ray, which appears to be frequently successful. When the glands break down, surgical interference is usually necessary.

Bone Tuberculosis.—This is likewise most common in children. It may be limited to the medulla or periosteum, and spread from either to the cortical portion, producing necrosis (tuberculous caries). It is most frequent at the joints, especially the hip and the intervertebral. Tuberculosis of the vertebral column is popularly called Pott's disease, or hunchback. It is usually associated with lumbar or psoas abscess. When localized to the vertebrae, cures are frequent. The treatment of Pott's disease and other joint tuberculous disease, like hip-joint disease, is similar to that of chronic tuberculosis of the lungs.

Intestinal Tuberculosis.—The intestines show either a miliary variety (the tubercle lying either beneath the mucous membrane or the peritoneum) or a chronic ulceration. Both forms are usually secondary to tuberculosis elsewhere. Miliary tuberculosis and tuberculous ulcers of the appendix are not uncommon, particularly in advanced tuberculosis of the lungs.

Laryngeal Tuberculosis.—This is manifested commonly by adults as a complication of advanced tuberculosis of the lungs. Its bad reputation, as far as cure is concerned, comes from the fact that it usually occurs only when the tuberculosis of the lungs is so advanced that the individual is incurable on account of the lung condition. When it occurs early in the case or as a primary affection, it is just as curable as tuberculosis elsewhere. The amount of hoarseness or pain does not indicate the seriousness of the condition. A small insignificant closed tubercle between the vocal cords may produce marked hoarseness; a small ulcer on the epiglottis may produce great pain; a large, much more serious ulcer when situated elsewhere may produce neither hoarseness nor pain.

The organs most commonly affected in adults are the lungs; in children, the lymph-glands, bones and joints. The other organs are affected much less frequently, and in about the following order: Intestines, peritoneum, kidneys, meninges, brain, spleen, liver, generative organs, pericardium, heart. Tuberculosis of the skin comes under the head of lupus (q.v.).

Symptoms and Prognosis of Tuberculosis of the Lungs.—It is necessary to differentiate three varieties, acute miliary tuberculosis, acute tuberculous pneumonia and chronic tuberculosis.

Acute Miliary Tuberculosis of the Lungs.—This may begin as a primary or be secondary to an acute or chronic affection elsewhere. It is most common as a termination of a chronic affection of the lungs. It comes on rather rapidly, like the ordinary acute infectious diseases, and is sometimes distinguished from them (especially typhoid fever) with difficulty. There is a loss of appetite, loss of flesh and strength, fever (102° to 104° F.), accelerated pulse, hurried respirations, a brown fissured tongue, delirium, then stupor and death. The duration is from two to four weeks. The prognosis is always grave, though no case of tuberculosis is ever so grave that treatment is surely in vain.

Acute Tuberculous Pneumonia.—This is practically always secondary to a chronic tuberculosis of the lungs. It begins, like lobar (ordinary) pneumonia, with a chill, high fever, rapid pulse, shortness of breath, hemorrhagic sputum, flushed face, and the physical signs of consolidation of parts of the lung. Instead of ending by crisis about the ninth day, like lobar pneumonia, it continues to a fatal termination; or the acute symptoms gradually subside, the diseased area becomes fibrous, and the patient gradually gets well, or approximately so, with a loss of lung-tissue equal to the involvement, which is sometimes an entire lung. The diagnosis is made by the ordinary signs of pneumonia and the tubercle-bacilli in the sputum. The prognosis is very unfavorable; rarely, however, a case recovers sufficiently to lead a useful life for a number of years. The treatment is that of chronic tuberculosis.

Chronic Tuberculosis of the Lungs.—This is what is ordinarily understood by consumption, or tuberculosis of the lungs without qualification. Its symptoms vary with the progress of the disease, and the susceptibility of the individual to the poison (toxin) excreted by the bacillus. The onset is usually insidious, and the disease frequently progresses for 5 to 20 years before the patient recognizes it. The symptoms are often brought out by a "cold" from which the patient seemingly does not recover. Many, therefore, attribute their disease to such a "cold." The first noticeable symptom is sometimes a hemorrhage or a pleurisy; again, a progressive loss in weight or a slight dry cough, becoming gradually worse. The most important very early symptoms are usually slight fever, especially toward evening (which may or may not be accompanied by a chill), hectic flush, acceleration of the pulse-rate, cough, expectoration, loss in weight, progressive pallor of the skin, night-sweats, indigestion or loss of appetite, vague general pains, and soreness localized in the chest. The one positive

sign of tuberculosis at this stage is the finding of tubercle-bacilli in the sputum. If every lesion were open, that is, in communication with a bronchus, there would be tubercle-bacilli in the sputum from the earliest stages, and the diagnosis would be easy; but many lesions are closed, that is, completely encapsulated, and, therefore, show no bacilli in the sputum. Hence the physician must rely on other signs brought out by careful inspection, palpation, percussion and auscultation of the chest and X-ray examination.

As the disease advances, all the foregoing symptoms are intensified. The pulse-rate becomes more rapid, so that it is evident to the patient in palpitation or shortness of breath, the temperature rises to 102 or more, the loss of weight becomes excessive, frequently reaching one-fourth, sometimes one-third and rarely one-half of the usual weight, the pallor becomes marked, the appetite is completely lost, cough may become almost continuous day and night and of a most racking character, expectoration increases, the feet usually swell and the picture presented is known to everybody. The patient is extremely emaciated, the chest is quite flat, the depressions above and below the clavicles are marked and the scapulae stand out prominently on the back. Hemorrhage may or may not occur. As a rule there is little or no pain. The lungs themselves possess no sensitive nerves, and it is only the associated pleurisy which occurs at intervals that produces this symptom. Examination by the physician now reveals the signs of extensive solidification. This may extend over one whole lung or over the greater part of both. It may or may not be associated with cavities.

Chronic tuberculosis of the lungs, when diagnosed sufficiently early, and when the personal resistance is good, is a very curable affection. This is proven by the number of cured lesions found at autopsy. It is very conservative to say that 50 per cent of all bodies coming to the autopsy table past the age of 35 (death having been the result of some other disease than tuberculosis of the lungs), show a healed lesion of tuberculosis of the lungs. The present post-mortem and clinical records demonstrate that 75 per cent of cases recover. Moreover, these post-mortem records are absolute; there is no practical question of diagnostic error. In addition, many cases with a lessened resistance can be so improved under judicious treatment that their lives are prolonged in comfort for 10, 20, even 30 years. For the encouragement of those afflicted, it might be stated that according to Jacobson the following appear to have suffered from tuberculosis: Cicero, Milton, Samuel Butler, Pope, Shelley, Hood, Keats, Elizabeth Barrett Browning, Francis Thompson, Goethe, Schiller, Molière, Richelieu, Mérimée, Thoreau, Calvin, Descartes, Locke, Kant, Spinoza, Mozart, Chopin, Paganini, Beaumont, Samuel Johnson, Sterne, DeQuincey, Scott, Jane Austen, Charlotte and Emily Bronte, Stevenson, Balzac, Voltaire, Rousseau, Washington Irving, Hawthorne, Gibbon, Kingsley, Ruskin, Emerson, Cardinal Manning, Raphael, Watteau, Bastien LePage, Marie Bashkirtseff, Cecil Rhodes and Laennec, as well as a large number of present-day physicians, who after developing the disease became tuberculosis experts,

like Edward L. Trudeau, Lawrence F. Flick, H. R. M. Landis, Lawrason Brown, A. M. Forster, James Price, Estes Nichols and E. S. Bullock.

Diagnosis.—Only rarely is the diagnosis difficult. The comparison of the autopsy findings with the clinical diagnosis at the Henry Phipps Institute showed the physical signs of Laennec to be practically perfect. In addition, we have as aids the examination of the sputum, the X-ray and the tuberculin test. Of these the physical signs elicited by an expert are the most positive. The sputum may fail to show tubercle bacilli on account of the lesion being closed. The tuberculin test is practically absolute, though it does not tell us in what part of the body the tuberculosis is. It is very useful in the diagnosis of tuberculosis in cattle because we only wish to learn the fact of its existence and are not concerned about its location; but not so useful in human beings in whom we usually wish to learn the nature of a lesion in a particular place. The X-ray in advanced tuberculosis is about as accurate as physical signs, but in early lesions it frequently fails. It is likely that time will make the X-ray more accurate.

Treatment of Chronic Tuberculosis of the Lungs.—There is no known specific for the disease. Koch's tuberculin is used by the minority of physicians and by them only in selected cases. There are at present more than 25 different tuberculins (emulsions and sera) on the market, and almost every discoverer claims his is the only one beneficial. The most that can be said with certainty in regard to the treatment with any of them is that in expert hands in small doses they do no harm. In the hands of inexperience their employment is fraught with danger. Whether tuberculin is used or not, the most careful hygienic régime must be instituted. The disease progresses on account of a lack of resistance in the patient; the object, therefore, is to increase the resisting power. This is accomplished by rest, fresh air and good nourishment. If the disease is active, that is associated with fever, rapid pulse or rapid emaciation, or other serious symptoms, rest in bed is necessary. The patient should remain in bed until the temperature is below 99.6, the pulse below 100, serious symptoms in abeyance and gain in weight is evident. An early favorable case usually requires from two to six weeks rest in bed; advanced cases correspondingly longer. Even when ready to be up all day he should lead a regular life, retiring at a proper hour (before 10 P.M. if an adult), in order to get sufficient rest. He should have nine hours' sleep, must sleep alone and, when possible, in a room alone. The best situation for the room is on the southwest corner of the house. The windows of the sleeping-room should be kept wide open, no matter what the weather. In summer all the windows in the room, and in winter, when the air diffuses much more readily, one window at least, should be wide open. The idea is to make every inhalation one of fresh air. During the day the patient must spend as much time as possible out of doors, yet in summer he must not be in the sun. When the weather is cold he should be comfortably wrapped. It is better to multiply the coverings which are readily removed than underclothes. Patients suspecting lung trouble

frequently come to the physician wearing a chest protector, two or even three undershirts and other clothes. This is not only unnecessary, but probably harmful. The regulation clothes of the kind most comfortable to the patient meet all requirements.

Diet.—Nourishment is most important. If a patient is run down, and he usually is, it is absolutely necessary to build him up. This can be accomplished only by a proper amount of food. Some physicians of repute in tuberculosis advise a general mixed diet with the addition of two to four pints of milk daily. Some push the nourishment; others, like Bushnell, insist that it should not be forced. In regard to nutritive value foodstuffs stand in the following order: Milk, eggs, meat, vegetables, cereals. Contrary to popular opinion potatoes never made anyone fat. An ordinary good diet would be: Breakfast, 7:30 A.M., fruit, two boiled eggs, bread and butter and two glasses of milk; lunch, 9:45 A.M., one glass of milk; dinner, 12:30 P.M., soup, meat (preferably rare roast beef or beefsteak), three kinds of vegetables and a simple dessert, like ice cream or rice pudding; lunch, 3:30 P.M., one glass of milk; supper, 6 P.M., meat or eggs, potatoes or other vegetable, bread and butter and two glasses of milk. The diet found most generally suitable to the great majority of patients at the Sanatorium for Consumptives at White Haven, Pa., is as follows: Breakfast, 7:30 A.M., one and one-half pints of milk, with two raw eggs (the eggs may be broken up in the milk or taken whole) and fruit; lunch, 10 A.M., one pint of milk and one raw egg; dinner, 12:30 P.M., soup, meat, three or four kinds of vegetables and pudding or ice cream; lunch, 3:30 P.M., one pint of milk and one raw egg; supper, 6 P.M., one and one-half pints of milk, two raw eggs and fruit; lunch, 8 P.M. (just before retiring), one-half to one pint of milk. Alcohol (whisky, brandy, wine, etc.), which was at one time much lauded, especially by the laity, is now avoided by experts.

Climate.—Up to recently considerable dependence was placed on climate. Patients who could afford it were advised to betake themselves to the Southwest, and not infrequently those who could not afford it were told to "beat their way." It is still generally believed that a dry climate is more suitable for the cure of the majority of patients; yet no matter what the climate, the patient must carry out the foregoing or a similar line of treatment. It is to be remembered that tuberculosis is a disease of all climes and altitudes; that cases develop in Colorado and New Mexico as well as in Canada, and that cases have been and are being cured in all parts of the world. Some writers, among them many eminent in the specialty of tuberculosis, absolutely deny any influence to climate. This, however, may be affirmed with certainty: that if the removal to another climate entails, or is likely to entail, the least hardship or privation, it is better for the patient to remain at home. Moreover, if the patient is sent away he must be referred to another physician, or to a sanatorium, where he will have a physician's care. To send him away to meet his difficulties and emergencies by himself is an acknowledgment on the part of the physician that he does not know how to treat

tuberculosis. Tuberculosis is, at least, as serious a disease as typhoid fever and requires analogous attention to detail. To send a tuberculous patient to a farmhouse or hotel in the country away from medical supervision is similar to instructing the family of a typhoid patient in the régime to be followed without returning to learn if the directions are carried out properly, or if new complications have taken place. In addition, in the hotel or boarding-house the patient is afraid to follow the régime too strictly, fearing that others will recognize his complaint, and he will be asked to leave. Moreover, to send a patient to a farmhouse where his disease is known has no further advantage. In this case the people have usually had tuberculous patients previously and have some ideas relative to the disease. These ideas are frequently wrong, yet wishing the patient well, they endeavor to instruct him. Any sick individual is more or less at the mercy of the well people about him; if they insist on certain things he has not the will-power to resist. He is, therefore, being treated by lay people not a physician.

Sanatoriums.—New sanatoriums for the treatment of tuberculosis are springing up almost every month. They are opening their doors as a result of private enterprise or benefaction or of a municipal crusade against the disease. They serve a three-fold purpose: (1) they gather in consumptives from large centres of population, and so prevent them from acting as a focus of contagion; (2) they instruct the patient how to take care of himself so that he is not a menace to others even when he returns home; (3) they demand a discipline which, if followed out, will in a favorable case cure. As a rule patients do better in sanatoriums than at home. There are a number of satisfactory sanatoriums throughout the United States, especially in the Northeast and Southwest quadrants.

Prevention in Cases of Chronic Tuberculosis of the Lungs.—The contagion is contained in the matter given off from a tuberculous sore. Therefore, in a case of tuberculosis of the lungs it is only necessary to destroy the sputum to prevent contagion to others. The patient should expectorate only into receptacles where the sputum can be properly handled without coming in contact with other things. He should never expectorate into rags or handkerchiefs, but should limit himself to spit-cup and paper napkins. The spit-cup should be made of paper so that it may be burned, or of china should contain an antiseptic or germicide. Ordinary lye will suffice. The cup should be boiled daily. When coughing, the patient should hold a paper napkin before his mouth. There should be no question of anyone sleeping with the patient. Children are especially susceptible; hence, when the parents are tuberculous, extra care must be exercised. The sick room should be uncarpeted, have no curtains or hangings and contain only the bed, a table, washstand and the necessary two or three chairs. Window shades are permissible. The room should be as open to the sunlight as possible in order to keep up constant disinfection. The patient, however, should not be in the sun. The eating utensils (knives, forks, spoons, cups, saucers, plates and glasses) should

be separate and should be boiled after use. Food of any kind left over should be burned; it must not be given to others, or even to the domestic animals, the cow, dog, pig or cat. The patient's soiled clothes should be handled as little as possible. When a change of clothes, sheets, pillow-cases, wearing apparel takes place, the soiled pieces should be rolled up in a clean sheet and boiled without unrolling. They may then be washed in the usual manner. If the patient is walking about the house, every room that he occupies should be as open as possible. He should not be allowed to make the dining-room or the kitchen his living-room. Nobody should leave the patient's room without washing the hands immediately. Children should not be allowed in the sick-room. If the patient dies, the bed and furniture should be taken outside and washed. Bureau drawers should be scrubbed. The mattress should be sent to a steam-cleaning establishment, or at least the stains on it washed with soap and water. Following this the mattress and furniture should be exposed to the sunlight for at least three or four days. The floor and woodwork of the room should be scrubbed and the room opened as much as possible to the air and sunlight for a week. A good working rule for all infectious diseases is that everything which has come in contact with the patient should be burned or boiled; if neither is feasible, it should be thoroughly scrubbed and exposed to the sunlight.

Campaign against Tuberculosis.—This is one of the most important public health issues of the day, and through it we expect the eradication of the disease. During the last 40 years the death rate of tuberculosis has fallen 50 per cent, due, at least, partly to the public health efforts against it. The prospect is sufficiently bright that every State, municipality and individual should be interested. Every municipality should have hospitals for early and advanced cases, dispensaries for the treatment of the poor, an anti-tuberculosis society for the education of the public and open-air schools for tuberculous children. Anti-spitting laws should be made and enforced. Tuberculosis should be on the list of notifiable diseases. Tuberculosis in cattle should be under administrative control. The individual can aid by voluntary work in connection with a hospital or dispensary, by membership in the anti-tuberculosis society or by donation of funds for the work.

Bibliography.—For scientific treatment of the subject, the following writings may be consulted: Laennec, 'Diseases of the Chest' (1823); Walshe, 'Diseases of the Lungs' (1860); Koch, 'Die Ätiologie der Tuberkulose' (in 'Berliner Klinische Wochenschrift,' No. 15, 1882); and 'Weitere Mitteilungen über der Tuberkulose' (in 'Deutsche Medizinische Wochenschrift,' 1891); and 'Ueber bakteriologische Forschung' ('Verhandlungen des X. Internationalen Medizinischen Congress,' Berlin, 4 Aug. 1890); and 'Relation of Human and Bovine Tuberculosis' (in 'Sixth International Congress on Tuberculosis,' Vol. IV, p. 645, 1908); Smith, 'A Comparative Study of Bovine Tubercle Bacilli and of Human Bacilli from Sputum' (in *Journal of Experimental Medicine*, 1898, III, p. 451); Cornet, 'Verbreitung der Tuberkelbacillen ausserhalb des Körpers' (in 'Zeitschrift für Hygiene,' 1888, Vol. V);

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In general it may be stated that the more the patient learns about tuberculosis the more he will understand the reasons for the directions of the physician and the more likely he is to carry them out. Every patient who can afford it, therefore, should join the National Tuberculosis Association (381 Fourth avenue, New York City), in order to receive the literature accompanying membership. In addition the following popular works are recommended: Flick, 'Crusade against Tuberculosis. Consumption a Curable and Preventable Disease. What a Layman should Know about it' (1903); Knopf, 'Pulmonary Tuberculosis: Its Modern Prophylaxis and the Treatment in Special Institutions and at Home' (1899); Brown, 'Rules for Recovery from Pulmonary Tuberculosis' (1916); Krause, 'Essays on Tuberculosis' (in *Journal of the Outdoor Life*, 1918-19); Carrington, 'Fresh Air and How to Use It' (1912), and 'Living and Sleeping in the Open Air' (1912); Minor, 'Hints and Helps for Tuberculous Patients'; Walsh, 'Onset of Tuberculosis' (in *Journal of the Outdoor Life*, August 1908), and 'Occupations for the Arrested Tuberculous' (in *Spunk*, August 1919); National Tuberculosis Association Standard Pamphlet, 'What you should know about Consumption' (1916); Otis, 'Tuberculosis, Its Cause, Cure and Prevention' (1918); King, 'The Battle with Tuberculosis and How to Win it' (1917); French, 'Home Care of Consumptives' (1916);

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TUBERCULOSIS, in cattle. See RINDERPEST.

TUBEROSE, tū'bē-rōs or tūb'rōz, an amaryllidaceous garden-flower (*Polianthes tuberosa*). The funnel-shaped perianth, an incurved tube, with somewhat rose-like lobes, often doubled in cultivation, has caused a misunderstanding as to the name, which properly refers to tuberous roots, but is generally pronounced as if it were "tube-rose." The flowers are creamy-white, waxen and brittle in texture, do not fade quickly, and are extremely fragrant, especially toward night. They are borne in a raceme at the top of a slender stem, from two to three feet tall. This stalk springs from a tuft of linear leaves, and is sheathed with the bases of others. The tube-rose is raised from bulbs, which are not hardy in the northern, but are grown for the trade very successfully in the southern, United States.

TUBES, Metal. See PIPE, MANUFACTURE OF.

TUBES, Pneumatic. See PNEUMATIC TUBES.

TUBES OF FORCE, imaginary tubular spaces in a field of force, and especially in a field of electric or magnetic force, whose bounding surfaces may be regarded as made up of lines of force. At any point in the surface of such a tube, the resultant force has a direction that is tangent to the tube. The conception is due to Faraday, and is very useful in forming a mental image of the physical state of a field of force. A tube of force cannot have a free end in any finite region of space. The tube must either return into itself, or pass off to an infinite distance, or terminate upon a mass of matter. The total number of lines of force included within a given tube of force is constant throughout the entire length of the tube; and hence it follows that the total force at all sections of the tube is the same; the intensity of a force varying inversely as the cross-section of the tube. In the case of an isolated electrified sphere, the tubes of electric force are radial cones, which converge, in external space, toward the centre of the sphere, but which terminate upon its surface. Also called "Tubes of Induction." See ELECTRICITY; MAGNETISM; INDUCTION.

TUBIGON, too-bē'gōn, Philippines, pueblo, province of Bohol, on the west coast; 24 miles northeast of Tagbilaran. It is on the coast highway. Pop. 15,860.

TÜBINGEN, tū'bing-ēn, Germany, a town in Württemberg, on the Neckar, 16 miles south of Stuttgart. The town stands in the midst of diversified scenery and is the seat of a national university. New buildings have been erected in connection with this flourishing institution, comprising various medical and physiological institutes. The university was founded in 1477.

The library contains 250,000 volumes. There are a botanical garden and fine scientific museums and collections, and an observatory. Names of celebrities connected with the university are Melancthon, Reuchlin and Baur. There is trade in agricultural produce, wine and fruits. Its chief history is connected with the 30 Years' War and the Reformation. Pop. 19,076.

TÜBINGEN SCHOOL, a name given to two separate and very different schools of philosophy, because their founders were connected with the famous University of Tübingen. The old school of Tübingen was orthodox, Gottlob Christian Storr, its founder (1746-1805), professor of philosophy at Tübingen in 1775, and professor of theology two years later, accepted without reserve the divine authority of the Scriptures, and defended miracles. Storr severely criticized Kant's book: 'Religion Within the Limits of Pure Reason,' and he set forth his own system in a work called 'Theory of Christian Doctrine Drawn from the Scriptures.' The later or modern school is that of Ferdinand Christian Baur (1792-1860), also professor of theology at Tübingen. Besides attacking the authenticity of certain of the Pauline epistles, he attempted to show that the fourth Gospel was not genuine. He admitted the morality of Christianity, but denied the miracles attributed to Christ and his apostles. Although Baur moderated his tone in later years his teachings promoted the spread of unbelief, and the 'Life of Jesus' by Strauss (1832), which attempted to show the Gospel to be a philosophic myth, was the outcome in a large degree of the critical studies of Baur. In 1915 there were 2,056 students and 128 instructors, but before the war the student body was much larger. Consult Pfeleiderer, Otto, 'Development of Theology in Germany since Kant' (London 1890); Nash, H. S., 'The History of the Higher Criticism of the New Testament' (New York 1906); Moore, E. C., 'Outline of the History of Christian Thought since Kant' (1912).

TUBMAN, Harriet, negro abolitionist and philanthropist: b. in slavery about 1815; d. Auburn, N. Y., 10 March 1913. She escaped from her master's plantation in Maryland when about 25 years of age, visited Garrison Brown and other Abolitionists and became an active promoter of the "underground railway." She first rescued her parents and during the two decades before the Civil War made repeated journeys to the South and brought a total of 400 or more of her race to the North and into Canada. During the war she served with the Massachusetts troops as a scout and guided Colonel Montgomery in his memorable expedition into South Carolina. By the friendly help of Secretary Seward she was able to make her home in Auburn, N. Y., after the war, and there soon became engaged in philanthropic service in behalf of the poor and aged of her people. Her efforts led to the Foundation of the Harriet Tubman Home for Indigent Aged Negroes, to which she gave personal oversight until 1908. She married in the South in early life a man named Tubman, who died, and later married Nelson Davis.

TUBUAI, too-boo-ī, or **AUSTRAL ISLANDS**, Polynesia, a group of islands belong-