

of the cathode, and under the influence of the anode decomposition is delayed and perhaps synthetic changes produced, whence a condition of positivity is developed near the anode. He says that later he gave this theory up for a better one, but it has been accepted by many and was brought forward again by Hering and Biedermann ("Ber. d. Oesterr. Akad. Math. Naturwiss. Cl.," Abthl. 3, Bd. 997, S. 145, 1888; Biedermann, "Electro-physiologie," S. 706, Jena, 1895), who described electrotonus of the nerve as a physiological phenomenon and different from the physical change to be observed on core-conductor models. Through this some confusion in terminology arose. Bernstein classes under physiological electrotonus the changes in irritability, and under physical the galvanic phenomena produced by the current. Hermann is not satisfied that such a division is admissible, nor is it now generally accepted. Hermann (*loc. cit.*, S. 280) says: "For me all physiological phenomena of electrotonus are only effects of polarization of the nerve core, these being at once the result of the action of the current and the cause of its spread into the extrapolar regions." The assumed assimilation and dissimilation effects find place under the physiological action of positive and negative polarization. Borutttau (Pflüger's *Archiv*, lviii., S. 51, 1894; lix., S. 47, 1895; lxiii., S. 154, 1896; lxvii., 1897; lxviii., 1897; lxxxi., S. 360, 1901), in his many papers on this subject, favors the view that excitation always goes hand-in-hand with a catelectrotonic condition and that the current of action can be identified with "a wave-like spread of catelectrotonus." He arrived at the view through his experiments on core-conductor models, on which he claims that all the electrical phenomena to be observed on nerves can be reproduced. His experiments have shown an astonishing similarity between the way in which electrical waves traverse these models and the way that the waves which accompany the nerve impulse pass along the nerve. Even very brief currents, such as induction currents, can cause catelectrotonus; and he finds that if a series of equal induction currents of alternating direction are passed through a portion of a core-conductor model, the opposite equal polarization effects cause a condition of negativity, of catelectrotonus, to develop near the electrodes on each side of the polarized region. Hoorweg (Pflüger's *Archiv*, lxxi., S. 128, 1898) as the result of his experiments comes to much the same conclusion as Borutttau, but Hermann (Pflüger's *Archiv*, lxxi., S. 294, 1898) states that he is not prepared to go as far as Borutttau, and does not consider that core-conductor models can be looked upon as nerve models in respect to irritability; they are, for him, models of electrotonic effects of the current. He considers that polarization, and the excitation associated with its development and disappearance, are to be held as distinctly separate phenomena. This year he writes (Pflüger's *Archiv*, lxxxiii., S. 360, 1901) with reference to the current of action and excitation: "One need not consider these as separate properties; on the contrary, for me excitation is nothing more than that change in the core which causes the potential of the current of action."

Pflüger found that the sudden cessation of anelectrotonus as well as the establishment of catelectrotonus is associated with a sudden rise of irritability and excitation. This is difficult to explain on the theory that excitation only occurs on the establishment of catelectrotonus. Gruetzner (*Breslauer aerztl. Zeitschr.*, No. 233, 1882) and Tigerstedt ("Mitthl. a. d. physiol. lab. d. Carolin. Instit. in Stockholm," Hft. 2, Abthl. 2, 1882) have tried to meet the difficulty by attracting attention to the fact that on the opening of the polarizing circuit a catelectrotonic condition is developed at the former anode, through the establishment of the polarization after-current of opposite direction. This explanation is not altogether satisfactory to Gotch (Schaefer's "Textbook of Physiology," ii., p. 499, 509, 1900) who points out a number of difficulties, and decides that something more than the effect of the after-polarization current must be at work in the production of the opening excitation; it appears to have been accepted by Hermann, Borutttau,

and others who associate excitation with the catelectrotonic state.

The prolonged, more or less continuous excitatory condition seen to follow the opening of a strong current that has flowed through a nerve for a considerable time, and which is known as "Ritter's opening tetanus," like the continuous contraction which may develop during the flow of a strong current, is generally attributed to an irritation caused by the ions liberated at the two poles during the flow of the current.

*Relation of Polarization to Conduction.*—The excitation process is transmitted in nerves in the form of a wave, at a definite rate, without loss of energy; electrotonus is developed instantaneously, is a stationary condition, and lessens in intensity with increasing distance. As Waller ("Lectures on Animal Electricity," p. 114, London, 1897) states, both electrotonic currents and currents of action are expressions of polarization, but the former is a stable, the latter a fleeting change, propagated as a wave along the compound electrolyte. If this be true, how can the excitation associated with the development of catelectrotonus result in conduction? Hermann (Pflüger's *Archiv*, lxxv., S. 574, 1899) recalls that as early as 1872 he expressed the view that the polarization which occurs at the bounding surfaces of the axis cylinder and the sheath of the nerve might play a part in the conduction process. He says there are two laws of the utmost importance in this connection, that of Pflüger, that a part of a nerve is irritated when catelectrotonus increases and when anelectrotonus diminishes, and his own law of the current of action, that every cross section of a fibre is negative in respect to one less irritated or not irritated. Since an irritated part of a core is negative with reference to neighboring parts which are at rest, currents would be set up which would flow from the core through the sheath and back to the core. These currents would act catelectrotonically to excite the neighboring inactive parts, and anelectrotonically to inhibit the part which had been irritated. On this basis, as the wave of excitation passes, each point becomes first catelectrotonic and then anelectrotonic. The idea that an anelectrotonic condition immediately follows a catelectrotonic explains for Hermann why it is that not all the available energy-producing substance made irritable by the condition of catelectrotonus is used up by a single excitation. Werigo (Pflüger's *Archiv*, lxxxiv., S. 618, 1901) thinks that it is unnecessary that anelectrotonus should thus follow catelectrotonus, because, if currents are of short duration, the rapid rise of excitability at the cathode is always followed by an immediate fall of excitability. Hermann (Pflüger's *Archiv*, lxxiv., S. 582, 1899), at the close of a paper in which he attempts to give a mathematical expression to his theory of nerve excitation, writes, "The irritation works on the current formation just like self-induction," but he says that we cannot assume self-induction for protoplasm.

Hermann's theory of the conduction process requires excitability in the conducting part, and the claim has been made by a number of investigators (Gruenhagen, Efron, Gad and Sawyer, Goldscheider, Piotrowsky) that they have observed conductivity in parts of a nerve which had lost their excitability, through the application of cold or some narcotizing drug. The excitation wave is evidently closely associated with a wave of electrical negativity, but the question arises, Are these to be regarded as inseparable in the case of nerves? The current of action can be demonstrated on a core-conductor model where there can be no question of excitation; and, as Hermann observes, a platinum wire is not a model of an irritable nerve, but only one to illustrate its electrical properties. Gotch and Burch (*Journ. of Physiol.*, xxiv., p. 144) found in experiments in which two rapidly following excitations were given to a nerve, different parts of which were at different temperatures, that excitation can pass along a stretch of nerve without a current of action developing. Herzen (*Centralbl. f. Physiol.*, xiii., S. 455; *Revue Scientifique*, January 13th, 1900) found that a nerve poisoned with chloral, and presumably not irritable (since no mus-

cular contractions resulted from excitation), was still able to conduct and give a negative variation. Radzikowski ("Ins. Solway, Travaux de lab.," iii., fasc. 1, p. 1, 1899) found currents of action in nerves which were apparently not functioning, since they did not excite the muscles. According to him, the current of action is simply a chemico-physical change resulting from the core-conductor structure, and not essentially connected with function. These results are by no means generally accepted. Thus Wedensky (Pflüger's *Archiv*, lxxxii., S. 124, 1900) considers that excitability and conductivity are inseparably connected, and Borutttau (Pflüger's *Archiv*, lxxxi., S. 360, 1900; lxxxiv., S. 325, 1901), after reviewing the work that has been done by others on this subject and describing a large number of experiments of his own, concludes with a reiteration of the view, already frequently expressed by him, that the appearance of currents of action without true functional activity of the nerve or the reverse never occurs.

There can be no doubt that electrolysis and the consequent polarization phenomena can exist independently of excitation, for they are to be observed on core-conductor models in which there is no question of excitation in the physiological sense. All the electrical phenomena to be detected on nerves can be reproduced on core-conductor models, and, therefore, we are justified in assuming that in the nerve as in the model they may be chemico-physical processes. This conclusion does not prevent us from considering the electrical phenomena detected in nerves as physiological processes, for they are to be found in nerves only so long as the chemical and anatomical structure peculiar to living protoplasm is maintained, and are modified by any influence which alters the functional activity of the tissue. Probably strengths of current capable of producing excitation will always produce, if suitably applied, polarization, but it by no means is sure that polarization effects may not occur independently of excitation.

Although we cannot say that polarization and excitation are identical, it is evident that they are very closely related and can be considered as two different symptoms of the same chemico-physical changes of the living protoplasm. The closeness of the relation is made evident by the fact that they are influenced in the same way by so many different conditions. Both excitation effects and polarization are most marked in medullated nerves; both require the integrity of the nerve fibre, and both are altered in a similar manner by most of the influences which affect the activity of nerve protoplasm; both are increased when the length of nerve subjected to the current is increased; both are increased by an increase in the intensity and duration of the current; currents of very short duration, such as induction currents, can produce polarization as well as excitation; finally, the more rapidly polarization develops the greater the excitation.

Warren P. Lombard.

**ELEMI.**—Of the several resins which at one time or another have been sold under this name, that in use at present is the one known as Manila elemi, and comes from the Philippines.

Elemi exudes from incisions in the bark of one or more species of *Canarium* (fam. *Burseraceae*). *C. commune* L., of India, yields one variety, but it is apparently not that now in use, which comes chiefly from the island of Luzon.

Elemi is a soft, translucent, grayish-white or yellowish substance, of pleasant aromatic odor, and rather terebinthinous taste. It comes in large cakes or masses, often very much contaminated with dirt, chips, and leaves. The British official description is as follows: "When fresh, soft, granular, resinous, and colorless, but by keeping it becomes harder, and of a pale yellow tint. Odor, strong and fragrant, somewhat resembling fennel. Moistened with rectified spirit, it breaks up into small particles, which, when examined by the microscope, are seen partly to consist of acicular crystals."

**COMPOSITION.**—According to Flückiger it contains ten per cent. of *essential oil*, which may be separated upon fractional distillation into six portions, all of the turpentine series,  $C_{10}H_{16}$ , or  $C_8H_8$ . The remaining resin is a complex mixture, from which several crystalline, resinous substances—*amyrin*, *bryoidin*, *breidin*, etc.—and amorphous resins have been separated. *Elemic acid* is finally another ingredient.

**ACTION AND USE.**—Elemi is a local stimulant, like turpentine and resin, and is put to the same uses. Its only employment here, and that quite rarely, is as an ingredient of plasters and ointments. *Unguentum Elemi* was made of elemi one part and simple ointment four parts. W. P. Bolles.

**ELEPHANTIASIS.**—(Synonym: Elephantiasis Arabum; Barbadoes leg; Morbus herculeus; Spargosis of the Egyptians; Pachydermia; Sarcoma mucosum; Tropical big leg; Bucnemias tropica; Hypersarcosis; Phlegmasia malabarica; Mal de Cayenne.)

**DEFINITION.**—A non-contagious endemic or sporadic disease, characterized by a chronic hyperplasia of the true skin and subcutaneous tissues; usually limited to an exclusive locality, and preceded by a local disturbance of the circulation, especially in the lymphatic vessels; and terminating in swelling, oedema, induration, progressive hypertrophy, more or less pigmentation, the development of fissures, and the growth of the papillae.

Owing to its great antiquity and the prominence awarded it by the earliest medical authorities, elephantiasis must be regarded as a disease of phenomenal interest. Its name would seem to imply that it originated in Arabia; indeed, according to the most ancient history of medicine, it first prevailed in that country and was of common occurrence. Formerly the term was practically unlimited in its application and failed to express with even approximate accuracy the various forms and phases of the disease. It apparently embraced all the morbid conditions of the human body which involved the enlargement of a specified part, and pointed particularly to the condition described as lepra graecorum. Truly, this was a most unfortunate name, as it was many times applied to lesions of a totally different pathological character. Happily, however, the employment of this generic term for diverse morbid processes has finally been discontinued, being at present confined to a single disease.

While elephantiasis is a typical pandemic disorder, characterized by wide differences, it is either endemic or sporadic in its distribution, differing symptomatically as to its exciting causes, but with like results in all cases.

The endemic form is essentially a disease of the tropical and subtropical regions, appearing most frequently in Africa, India, the Indian Archipelago, the West Indies and South America. The sporadic form occurs all over the world; the endemic type is rarely encountered beyond the 35th degree of North and South latitudes. In Travancore it is very common, affecting about five per cent. of the entire population, while in some of the South Pacific Islands nearly one-half of all the inhabitants are its victims.

In the United States the disease is comparatively rare, being more prevalent in our territorial possessions and in the South than in the North, where, indeed, it does not seem to spring from the same cause. The pathological process is so different in the two groups of the disease, as to etiology, symptomatology, and course, that there seem to be two distinct types of the disease, covering a multitude of hypertrophic conditions, such as result from congenital elephantiasis, telangiectodes and lymphangiectodes, or acquired obstruction of the lymphatic system, and including cases of chronic phlegmasia dolens and hypertrophy originating in chronic eczema and varicose veins.

The endemic form declares itself somewhat suddenly, and is accompanied by pain and inflammation of the parts affected, more or less well-marked febrile symptoms, and the so-called elephantoid fever which is usually

characterized by a prodromic stage, generally following over-exertion or injury, chills, high fever, and gastric disturbances.

The inflammation is of an erysipelatous character, and chooses the lymphatics and blood-vessels as its points of attack. Often the lymph glands of the groin and arm-

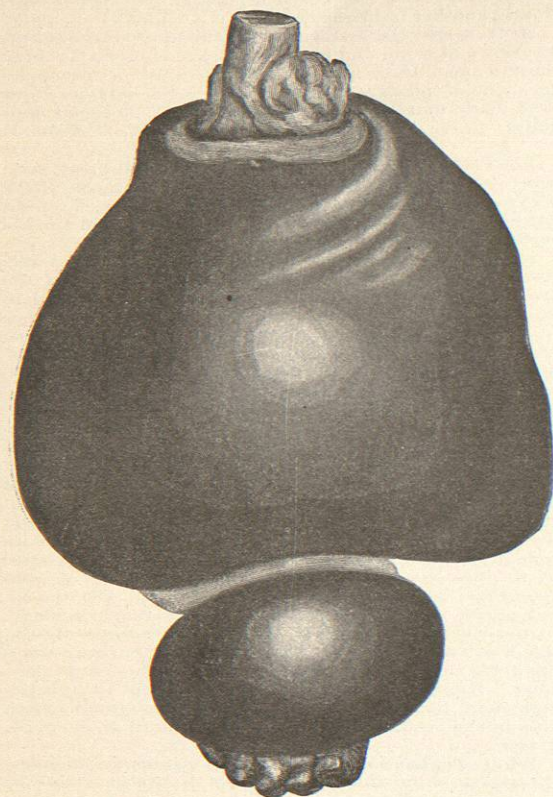


FIG. 1856.—Elephantiasis Tropica of Leg. (Crocker.)

pit become swollen and extremely sensitive. A lymphatic streak of a rose color is frequently seen to traverse the skin which, when palpated, seems to present a line of knots; the region involved becoming reddened, hot, painful, oedematous, and swollen.

In a few days the constitutional symptoms subside, and so also, as a rule, does the swelling; a slight thickening, however, may remain. The further course of the disease is marked by repeated attacks, at irregular intervals, of lymphangitis and lymphatic oedema. These may be repeated once or twice in a single month, or may be delayed for a whole year. As a rule, the oftener the attacks occur the less intense is the general reaction; while, on the other hand, there occurs, each time, additional hypertrophy of the region affected. Finally the affected part becomes permanently enlarged, hard to the touch, and dark in color, with folds beneath which dirt and offensive discharges collect; hence the comparison, if the disease affects the lower extremity, to the elephant's leg. In the interval between any two attacks, if protracted, the swelling somewhat recedes, but afterward it increases again. As a consequence of the recurrent inflammation, enormous and persistent hypertrophies result. Sometimes there are slight tension and firmness of the affected parts, but at other times they show a discoloration consisting of various shades of red. After a

few attacks, a fold of skin, when pinched, reveals an appreciable thickening. Repeated attacks result in still further thickening of the skin and subcutaneous connective tissue, the skin becoming harder, firmer, non-resistant, and more tensely fastened to the substratum. In extreme cases, the deep fascia, the sheaths of the blood-vessels, and the periosteum are involved. The condition is furthermore favored by the stasis of the lymph in the channels and obstructed glands, resulting in a dilatation of the lymphatic trunks, which become indurated, tough, and stringy. Ultimately, they and the surrounding connective tissues become fused together into a uniform, hard mass.

The changes which take place upon the exterior of the integument, after the lapse of a year or more, are manifold. At first the skin is usually dry, shiny, smooth, and tense; a little later it becomes discolored and is found to be rough, tawny, ichthyotic, and pigmented. The natural folds and furrows are greatly exaggerated, and often present irregular fissures especially pronounced at the bases of the folds, under which the epidermis is apt to become macerated and decomposed, as a result of which there is an offensive discharge. The papillary layer is frequently modified in that it may be uniformly thickened like the whole skin, or this may occur only at certain points, forming the verrucous projections often encountered about the arch of the foot or between the folds of the integument. While the structural change of the papillary layer is not always the same, it may be said that thickening of the epidermis is generally associated with hypertrophic papillae.

This disease is calculated to give more or less annoyance to the patient, not alone because the parts are cumbersome, but for the reason that great deformities of the

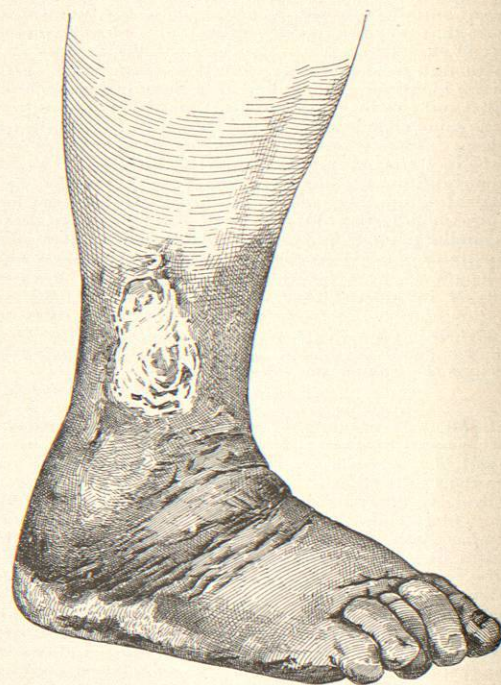


FIG. 1857.—Elephantiasis of the Leg Resulting from Varicose Ulcer. (Chatelain.)

toes may result from atrophy and dislocations. The nails, too, may contribute to the characteristic discomfort by undergoing some kind of degeneration. Occa-

sionally even the bones show a change. Osteophytes may arise, particularly near the insertion of a muscle or sinew, or at the borders of the epiphyses, and eventually the bone undergoes necrosis and ulceration. In addition to interference caused by the deformity, the function of the limb becomes greatly impaired from the hypertrophy of the structures of the soft parts and from atrophy of the bones and muscles. The resulting inconvenience is considerable, especially when the disease affects the lower portion of the leg. Other local discomforts may arise. Thus, for example, eczema is sometimes set up, at other times varicose ulcers are formed, and, in rare cases, rupture of the lymphatics ensues. All these are no doubt secondary consequences of the disease, but they greatly aggravate the suffering of the patient. Again, severe and continuous pain, usually of a neuralgic character, may accompany the disease. Occasionally elephantiasis may be associated with complications; these are found to be most numerous in the endemic variety. They consist, as a rule, of suppuration of the inguinal glands, and of cellulitis with subsequent abscess formations.

The sporadic form, like the endemic, very often declares itself in recurring attacks of lymphangitis, but differs from it in these particulars: the constitutional symptoms are not usually as severe, and the enlargement is more equally distributed about the limb and not so often associated with the section below the knee. Cases resulting wholly—or nearly so—from chronic irritation, without any acute inflammatory signs, would seem almost to constitute an entirely different class. However, these two types—the endemic and the sporadic—are so similar clinically that they must be considered as one. It is not difficult to see that repeated inflammations have greatly interfered with the venous and lymphatic circulation; the limb has therefore been chronically congested, and a superabundance of lymph has been constantly present in the subcutaneous cellular spaces. This condition finally becomes more pronounced and results in the hypertrophy and induration so characteristic of elephantiasis. In rare cases the acute and chronic inflammation, which may be regarded as the cause of the disease, are wanting.

The particular portion of the body most frequently attacked is the leg, yet the hypertrophy frequently appears elsewhere, as, for example, in the scrotum, penis, labia, hand, arm, face, and ears. Apart from the extremities it may be stated that it is most often met with in the scrotum, which has been known to attain a weight of more than one hundred pounds, and actually to reach the ground. When the male genitals become the seat of the difficulty, we have symptoms and complications peculiar to these parts. The symptoms referred to, in addition to the constitutional ones and the recurring attacks of lymphangitis, are both systemic and local. For, besides the usual chills and fever, we often encounter nausea and vomiting, associated with severe pains in the groin, radiating from the spermatic cord, with subsequent swelling of the locality. The attack may be acute, in consequence of the disturbance in the circulation, this being especially true when the inguinal glands are greatly inflamed and swollen, and when there is a chronic inflammatory affection of the penis and scrotum. Strictures, urinary fistulae, and incontinence of urine are frequently the source of the disease. The cutaneous covering of the scrotum and penis soon loses its sensitiveness and becomes indurated, rough, and rugose. The prepuce is lengthened and thickened and the skin gradually becomes hypertrophied. When the scrotum is involved, the raphe and the natural folds and furrows are greatly exaggerated; beneath these, dirt and dribbling urine from a retracted penis collect, and give rise to the formation of excoriations, fissures, and ulcerations, accompanied by offensive discharges. We also find hernia and hydrocele frequently associated, as complications, with elephantiasis of the scrotum.

Lymph scrotum is a peculiar form of the disease known as nevoid elephantiasis; this is frequently associated with hæmaturia, chyluria, and a varicose condition of the lym-

phatics of the scrotum, apparently due to the presence of the *Filaria sanguinis hominis*. It is characterized by the presence of enlarged vessels arranged in lines or groups, which vary in diameter from a pinhead to a bean, and which, being opened, exude a pinkish, milky fluid which readily coagulates. In its incipiency it is attended with chills, fever, and erysipelatous inflammations; the inguinal glands on one or both sides are swollen; and, sometimes, there is inflammation of the testicles.

Elephantiasis of the female genitals, in the temperate zone, is more frequently met with than its congener in man, but in the tropical and sub-tropical climates these organs are less often assailed. The parts generally affected are the vulva, the labia majora, less often the labia minora, and rarely the clitoris. The sporadic variety is remarkable in that it is comparatively mild and seldom presents the intense features found in the endemic type. In this variety the development of the disease may be slow and painless, or very rapid. It is usually characterized by symptoms which indicate that it is the result of some irritation, as onanism, or of some local affection, as syphilitic inflammation, which, in addition to the irritation, obstructs the circulation of the lymphatics. Benign tumors which appear early in childhood, or congenital malformations may serve to explain the subsequent hypertrophy.

The entire vulva is not always involved, but usually the labia majora become affected. Should the lesser labia fail to escape the influence of the disease, they will often become the seat of a spherical or pear-shaped tumor, for the most part small, although sometimes attaining considerable size. The skin restricted to this region may become either smooth and somewhat tense and firm, or wrinkled and covered with dilated sebaceous glands with gaping orifices; or it may show warty growths arising from the enlarged papillae. In the latter case the entire surface of the vulva, as far as to the anus, may be covered with these warty growths. The surface, owing to the presence of distinct and hypertrophic papillae, reveals numerous rifts and fissures. The development of the disease in these parts is generally quite slow, a number of years being necessary to produce tumors as large as a hen's egg, but at times the pathological change occurs more rapidly, and then the masses may attain enormous dimensions. Even when these growths are small, the patient often suffers from rhagades, fissures, and ulcerations, which, if not actually painful in themselves, are always troublesome by reason of the irritation caused by the acid excretions. The mucous membranes of the urethra and vagina also, under these conditions, often throw out a discharge which is of an irritating character.

While the various localities mentioned may be susceptible to elephantiasis, it would nevertheless appear that only the lower extremities and the genital organs, owing to the frequency with which they are attacked and the extent of the hypertrophy, deserve here to be considered. The portions of the body most usually attacked are the leg and the scrotum; all other sites are so rarely implicated that a detailed description thereof seems unnecessary, the characteristic symptoms having already been sufficiently indicated in discussing the preceding forms.

Elephantiasis of the face and head usually presents a lobulated appearance without well-defined borders. It generally results from frequent attacks of erysipelas, or it follows a chronic eczema, or, finally, it may be due to traumatism. The entire face may be affected, or only a single section, as the forehead, ears, lips, and nose. Elephantiasis of the mammae occurs only in women and never before puberty. It generally manifests itself during pregnancy or lactation and is almost invariably of the endemic type. In the tropics the female breast has been known to develop into a colossal tumor, large enough to extend down to the patient's knees, and at the same time the affected skin has shown a marked tendency to ulcerate.

Finally, elephantiasis is sometimes congenital. This form resembles the sporadic or the endemic variety in its anatomical characteristics, but differs from them not only