corpuscles rapidly disappear, and the milk-globules become more abundant, regular and uniform in size. It may be stated, in general terms, that the secretion of milk becomes fully established and all the characters of the colostrum disappear between the eighth and the tenth day after delivery. A few colostrum-corpuscles and masses of agglutinated milk-globules may sometimes be discovered after the tenth day, but they are rare. After the fifteenth day, the milk does not sensibly change in its microscopical or its chemical characters.

Lacteal Secretion in the Newly-Born.

In infants of both sexes there is generally a certain amount of secretion from the mammary glands, beginning at birth or two or three days after, and continuing sometimes for two or three weeks. The quantity of fluid that may be pressed out at the nipples at this time is very variable. Sometimes only a few drops can be obtained, but occasionally the fluid amounts to one or two drachms (3·7 or 7·4 grammes.) Although it is impossible to indicate the object of this secretion, which takes place when the glands are in a rudimentary condition, it has been so often observed and described by physiologists, that there can be no doubt with regard to the nature of the fluid and the fact that the secretion is almost always produced in greater or less quantity. The following is an analysis by Quevenne of the secretion obtained by Gubler. The observations of Gubler were made upon about twelve hundred children. The secretion rarely continued for more than four weeks, but in four instances it persisted for two months.

COMPOSITION OF THE MILK OF THE INFANT.

Water	894·00
Caseine	26·40
Sugar of milk	62.20
Butter	14·00
Earthy phosphates	1·20
Soluble salts (with a small quantity of insoluble phosphates)	2·20
	1,000·00

This fluid does not differ much in its composition from ordinary milk. The proportion of butter is much less, but the proportion of sugar is greater, and the quantity of caseine is nearly the same.

Of the other fluids which are enumerated in the list of secretions, the saliva, gastric juice, pancreatic juice and the intestinal fluids have already been described in connection with the physiology of digestion. The physiology of the lachrymal secretion will be taken up in connection with the eye, and the bile will be treated of fully under the head of excretion.

Secretory Nerve-Centres.—It remains now to consider the influence of nerve-centres upon certain secretions. Cerebro-spinal centres presiding over secretion have not been determined for all of the glands, although they may exist. No cerebro-spinal centres have been described for the secretions of

mucous membranes, the gastric juice, the intestinal juice, the sebaceous fluids, the milk or the lachrymal fluid.

The centres for the salivary secretions are in the medulla oblongata, near the points of origin of the facial and glosso-pharyngeal nerves. The centre for the pancreatic secretion is also in the medulla oblongata. The centres which act upon the liver and upon certain excretions will be treated of in connection with the physiology of the liver, kidneys and skin.

CHAPTER XII.

EXCRETION BY THE SKIN AND KIDNEYS.

Differences between the secretions proper and the excretions—Physiological anatomy of the skin—Physiological anatomy of the nails—Physiological anatomy of the hairs—Sudden blanching of the hair—Perspiration—Sudoriparous glands—Mechanism of the secretion of sweat—Properties and composition of the sweat—Peculiarities of the sweat in certain parts—Physiological anatomy of the kidneys—Mechanism of the production and discharge of urine—Influence of blood-pressure, the nervous system etc., upon the secretion of urine—Physiological anatomy of the urinary passages—Mechanism of the discharge of urine—Properties and composition of the urine—Influence of ingesta upon the composition of the urine and upon the elimination of nitrogen—Influence of muscular exercise upon the elimination of nitrogen—Water regarded as a product of excretion—Variations in the composition of the urine.

In entering upon the study of the elimination of effete matters, it is necessary to appreciate fully the distinctions between the secretions proper and the excretions, in their composition, the mechanism of their production, and their destination. The urine may be taken as the type of the excrementitious fluids. None of its normal constituents belong to the class of non-crystallizable, organic nitrogenized matters, but it is composed entirely of crystallizable matters, simply held in solution in water. The solid constituents of the urine represent the ultimate physiological changes of certain parts of the organism, and they are in such a condition that they are of no farther use in the economy and are simply discharged from the body. Certain inorganic matters are found in the excrementitious fluids, are discharged with the products of excretion, and are thus associated with the organic constituents of the body in their physiological changes as well as in their deposition in the tissues. Coagulable organic matters, or albuminoids, never exist in the excrementitious fluids under normal conditions; except as the products of other glands may become accidentally or constantly mixed with the excrementitious fluids proper. The same remark applies to the non-nitrogenized matters, sugars and fats, which, whether formed in the organism or taken as food, are consumed in the organism. The production of the excretions is constant, being subject only to certain modifications in activity, which are dependent upon varying conditions of the system. All of the elements of excretion pre-exist in the blood, either in the condition in which they are discharged or in some slightly modified form.

The urine is a purely excrementitious fluid. The perspiration and the

secretion of the axillary glands are excrementitious fluids, but they contain a certain quantity of the secretion of the sebaceous glands. Certain excrementitious matters are found in the bile, but at the same time, this fluid contains substances that are formed in the liver, and it has an important office as a secretion, in connection with the processes of digestion.

Physiological Anatomy of the Skin.

The skin is one of the most complex and important structures in the body, and it has a variety of uses. In the first place, it forms a protective covering for the general surface. It is quite thick over the parts most subject to pressure and friction, is elastic over movable parts and those liable to variations in size, and in many situations, is covered with hair, which affords an additional protection to the subjacent structures. The skin and its appendages are imperfect conductors of caloric, are capable of resisting very considerable variations in temperature, and they thus tend to maintain the normal standard of the animal heat. As an organ of sensibility, the skin has important uses, being abundantly supplied with sensory nerves, some of which present an arrangement peculiarly adapted to the nice appreciation of tactile impressions. The skin assists in preserving the external forms of the muscles. It also relieves the abrupt projections and depressions of the general surface and gives roundness and grace to the contours of the body. In some parts it is very closely attached to the subjacent structures, while in others it is less adherent and is provided with a layer of adipose tissue.

As an organ of excretion, the skin is very important; and although the quantity of excrementitious matter exhaled from it is not very great, the evaporation of water from the general surface is always considerable and is subject to such modifications as may become necessary from the varied conditions of the animal temperature. Thus, while the skin protects the body from external influences, its office is important in regulating the heat produced as one of the phenomena attendant upon the general process of nutrition.

As the skin presents such a variety of uses, its physiological anatomy is most conveniently considered in connection with different divisions of the subject of physiology. For example, under the head of secretion, the structure of the different varieties of sebaceous glands has already been described; and the anatomy of the skin as an organ of touch will be most appropriately considered in connection with the physiology of the nervous system. In connection with the excreting organs found in the skin, it will be convenient to describe briefly its general structure and the most important points in the anatomy of the epidermic appendages. A full and connected description of the skin and its appendages belongs properly to works upon anatomy.

Extent and Thickness of the Skin.—Sappey has made a number of observations upon the extent of the surface of the skin. Without detailing the measurements of different parts, it may be stated, as the general result of his observations, that the cutaneous surface in a good-sized man is equal to a little more than sixteen square feet (15,000 square centimetres); and in men of

more than ordinary size, it may extend to twenty-one or twenty-two square feet (2 square metres). In women of medium size, as the mean result of three observations, the surface was found to equal about twelve and a half square feet (11,500 square centimetres).

The thickness of the skin varies very much in different parts. Where it is exposed to constant pressure and friction, as on the soles of the feet or the palms of the hands, the epidermis becomes very much thickened, and in this way the more delicate structure of the true skin is protected. It is well known that the development of the epidermis, under these conditions, varies in different persons, with the pressure and friction to which the surface is habitually subjected. The true skin is $\frac{1}{12}$ to $\frac{1}{8}$ of an inch (2·1 to 3·2 mm.) in thickness; but in certain parts, particularly in the external auditory meatus, the lips and the glans penis, it frequently measures not more than $\frac{1}{100}$ of an inch (0·254 mm.).

Layers of the Skin.—The skin is naturally divided into two principal layers, which may be readily separated from each other by maceration. These are the true skin—cutis vera, derma, or corium—and the epidermis, cuticle, or scarf-skin. The true skin is more or less closely attached to the subjacent structures by a fibrous structure called the subcutaneous areolar tissue, in the meshes of which there is usually a certain quantity of adipose tissue. This layer is sometimes described under the name of the panniculus adiposus. The thickness of the adipose layer varies very much in different parts of the general surface and in different persons. There is no fat beneath the skin of the eyelids, the upper and outer part of the ear, the penis and the scrotum. Beneath the skin of the cranium, the nose, the neck, the dorsum of the hand and foot, the knee and the elbow, the fatty layer is about $\frac{1}{12}$ of an inch (2·1 mm.) in thickness. In other parts it usually measures $\frac{1}{6}$ to $\frac{1}{2}$ of an inch (4·2 to 12·7 mm.). In very fat persons it may measure an inch (25·4 mm.) or more. Upon the head and the neck, in the human subject, are muscles attached more or less closely to the skin. These are capable of moving the skin to a slight extent. Muscles of this kind are largely developed and quite extensively distributed in some of the lower animals.

There is no sharply defined line of demarcation between the cutis and the subcutaneous areolar tissue; and the under surface of the skin is always irregular, from the presence of fibres which are necessarily divided in detaching it from the subjacent structures. The fibres which enter into the composition of the skin become looser in their arrangement near its under surface, the change taking place rather abruptly, until they present large alveoli, which generally contain a certain quantity of adipose tissue.

The layer called the true skin is subdivided into a deep, reticulated or fibrous layer, and a superficial portion, called the papillary layer. The epidermis is also divided into two layers, as follows: an external layer, called the horny layer; and an internal layer, called the Malpighian, or the mucous layer, which is in contact with the papillary layer of the corium.

The Corium, or True Skin.—The reticulated and the papillary layers of the true skin are quite distinct. The lower stratum, the reticulated layer, is

much thicker than the papillary layer and is dense, resisting, quite elastic and slightly contractile. It is composed of bundles of fibrous tissue, interlacing with each other in every direction, generally at acute angles. Distributed throughout this layer, are found anastomosing elastic fibres of the small variety, and with them a number of non-striated muscular fibres. This portion of the skin contains, in addition, a considerable quantity of amorphous matter, which serves to hold the fibres together. The muscular fibres are particularly abundant about the hair-follicles and the sebaceous glands connected with them, and their arrangement is such that when they are excited to contraction by cold or by electricity, the follicles are drawn up, projecting upon the general surface and producing the appearance known as "goose-flesh." Contraction of these fibres is particularly marked about the nipple, producing the so-called erection of this organ, and about the scrotum and penis, wrinkling the skin of these parts. The peculiar arrangement of the little muscles around the hair-follicles, forming little bands attached to the surface of the true skin and the base of the follicles, explains fully the manner in which the "goose-flesh" is produced. (See Fig. 107, page 349.) Contraction of the skin, under the stimulus of electricity, has been repeatedly demonstrated, both in the living subject and in executed criminals immediately after death.

The papillary layer of the skin passes insensibly into the subjacent structure without any marked line of division. It is composed chiefly of amorphous matter like that which exists in the reticulated layer. The papillæ themselves appear to be simple elevations of this amorphous matter, although they contain a few fibres, connective-tissue nuclei and little corpuscular bodies called cytoblastions (Robin).

As regards their form, the papillæ may be divided into two varieties; the simple and the compound. The simple papillæ are conical, rounded or club-shaped elevations of the amorphous matter and are irregularly distributed on the general surface. The smallest are $\frac{1}{700}$ to $\frac{1}{400}$ of an inch (36 to 62 μ) in length and are found chiefly upon the face. The largest are on the palms of the hands, the soles of the feet, and the nipple. These measure $\frac{1}{250}$ to $\frac{1}{200}$ of an inch (100 to 125 μ). Large papillæ, regularly arranged in a longitudinal direction, are found beneath the nails. The regular, curved lines observed upon the palms of the hands and the soles of the feet, particularly the palmar surfaces of the last phalanges, are formed by double rows of compound papillæ, which present two, three or four elevations attached to a single base. In the centre of each of these double rows of papillæ, is a fine and shallow groove, in which are found the orifices of the sudoriferous ducts.

The papillæ are abundantly supplied with blood-vessels terminating in looped capillary plexuses and with nerves. The termination of the nerves is peculiar and will be fully described in connection with the organs of touch. The arrangement of the lymphatics, which are very abundant in the skin, has already been indicated in the general description of the lymphatic system.

The Epidermis and its Appendages.—The epidermis, or external layer of the skin, is composed of cells. It has neither blood-vessels, nerves nor lymphatics. Its external surface is marked by shallow grooves, which correspond to the deep furrows between the papillæ of the derma. Its internal surface is applied directly to the papillary layer of the true skin and follows closely all its inequalities. This portion of the skin is subdivided into two tolerably distinct layers. The internal layer is called the rete mucosum, or the Malpighian layer, and the external is called the horny layer. These two layers present certain important distinctive characters.

The Malpighian layer is composed of a single stratum of prismoidal, nucleated cells, containing pigmentary matter, which are applied directly to all the inequalities of the derma, and of a number of layers of rounded cells containing no pigment. The upper layers of cells, with the scales of the horny layer, are semi-transparent and nearly colorless; and it is the pigmentary layer chiefly which gives to the skin its characteristic color and the peculiarities in the complexion of different races and of different individuals. All the epidermic cells are somewhat colored in the dark races, but the upper layers contain no pigmentary granules. The thickness of the rete mucosum is $\frac{1}{1700}$ to $\frac{1}{75}$ of an inch (15 to 333 μ).

The horny layer is composed of a number of strata of hard, flattened cells, irregularly polygonal in shape and generally without nuclei. The deeper cells are thicker and more rounded than those of the superficial layers.

The epidermis serves as a protection to the more delicate structure of the true skin, and its thickness is in proportion to the exposure of the different parts. It is consequently much thicker upon the soles of the feet and the palms of the hands than in other portions of the general surface, and its thickness is very much increased in those who are habitually engaged in manual labor. Upon the face and eyelids, and in the external auditory passages, the epidermis is most delicate. The variations in thickness depend entirely upon the development of the horny layer. The thickness of the rete mucosum, although it varies in different parts, is rather more uniform.

There is constantly more or less desquamation of the epidermis, particularly of the horny layer, and the cells are regenerated from the subjacent parts. It is probable that there is a constant formation of cells in the deeper strata of the horny layer, which become flattened as they near the surface; but there is no direct evidence that the cells of the rete mucosum undergo transformation into the hard, flattened scales of the horny layer.

Physiological Anatomy of the Nails.—The nails are situated on the dorsal surfaces of the distal phalanges of the fingers and toes. They serve to protect these parts, and in the fingers, they are quite important in prehension. The general appearance of the nails is sufficiently familiar. In their description, anatomists have distinguished a root, a body and a free border.

The root of the nail is thin and soft, terminating in rather a jagged edge, which is turned slightly upward and is received into a fold of the skin, extending around the nail to its free edge. The length of the root varies with the size of the nail, but it is generally one-fourth to one-third of the length of the body.

The body of the nail extends from the fold of skin which covers the root,

to the free border. This portion of the nail, with the root, is closely adherent by its under surface to the true skin. It is marked by fine but distinct longitudinal striæ and very faint transverse lines. It usually is reddish in color on account of the great vascularity of the subjacent structure. At the posterior part, is a whitish portion, of a semilunar shape, called the lunula, which has this appearance simply from the fact that the corium in this part is less vascular and the papillæ are not so regular as in the rest of the body. That portion of the skin situated beneath the root and the body of the nail is called the matrix. It presents highly vascular papillæ, arranged in regular, longitudinal rows, and it receives into its grooves corresponding ridges on the under surface of the nail.

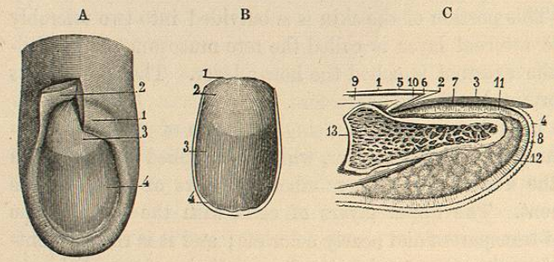

FIG. 105.—*Anatomy of the nails* (Sappey).

A, nail *in situ:* 1, cutaneous fold covering the root of the nail; 2, section of this fold, turned back to show the root of the nail; 3, lunula; 4, nail.
B, concave or adherent surface of the nail: 1, border of the root; 2, lunula and root; 3, body; 4, free border.
C, longitudinal section of the nail: 1, 2, epidermis; 3, superficial layer of the nail; 4, epidermis of the pulp of the finger; 5, 6, true skin; 7, 11, bed of the nail; 8, Malpighian layer of the pulp of the finger; 9, 10, true skin on the dorsal surface of the finger; 12, true skin of the pulp of the finger; 13, last phalanx of the finger.

The free border of the nail begins where the nail becomes detached from the skin. This is generally cut or worn away and is constantly growing; but if left to itself, it attains in time a definite length, which may be stated, in general terms, to be an inch and a half to two inches (40 to 50 mm.).

On examining the nail in a longitudinal section, the horny layer, which is usually regarded as the true nail, is found to increase progressively in thickness from the root to near the free border. If the nail be examined in a transverse section, it will also be found much thicker in the central portion than near the edge, and that part which is received into the lateral portions of the fold becomes excessively thin like the rest of the root. The nail becomes somewhat thinner at and near the free border.

Sections of the nails show that they are composed of two layers, which correspond to the Malpighian and the horny layers of the epidermis, although they are much more distinct. The Malpighian layer is applied directly to the ridges of the bed of the nail and presents upon its upper surface ridges much less strongly marked than those of the underlying true skin. This layer is rather thinner than the horny layer, is whitish in color, and is composed of a number of strata of elongated, prismoidal, nucleated cells, arranged perpendicularly to the matrix.

The horny layer, which constitutes the true nail, is applied by its under surface directly to the ridges of the Malpighian layer. It is dense and brittle and is composed of strata of flattened cells which can not be isolated without

the use of reagents. If the different strata of this portion of the nail be studied after boiling in a dilute solution of sodium or potassium hydrate, it becomes evident that here, as in the horny layer of the epidermis, the lower cells are rounded, while those nearer the surface are flattened. These cells are nearly all nucleated. The thickness of this layer varies in different portions of the nail, while that of the Malpighian layer is nearly uniform. This layer is constantly growing, and it constitutes the entire substance of the free borders of the nails.

The connections of the nails with the true skin resemble those of the epidermis; but the relations of these structures to the epidermis itself are somewhat peculiar. Before the fourth month of fœtal life, the epidermis covering the dorsal surfaces of the last phalanges of the fingers and toes does not present any marked peculiarities; but at about the fourth month, the peculiar hard cells of the horny layer of the nails make their appearance between the Malpighian and the horny layer of the epidermis, and at the same time the Malpighian layer beneath this plate, which is destined to become the Malpighian layer of the nails, is thickened and the cells assume a more elongated form. The horny layer of the nails constantly thickens from this time; but until the end of the fifth month, it is covered by the horny layer of the epidermis. After the fifth month, the epidermis breaks away and disappears from the surface; and at the seventh month, the nails begin to increase in length. Thus, at one time, the nails are actually included between the two layers of the epidermis; but after they have become developed, they are simply covered at their roots by a narrow border of the horny layer. The nails are therefore to be regarded as modifications of the horny layer of the epidermis, possessing certain anatomical and chemical peculiarities. The Malpighian layer of the nails is continuous with the same layer of the epidermis, but the horny layers are distinct.

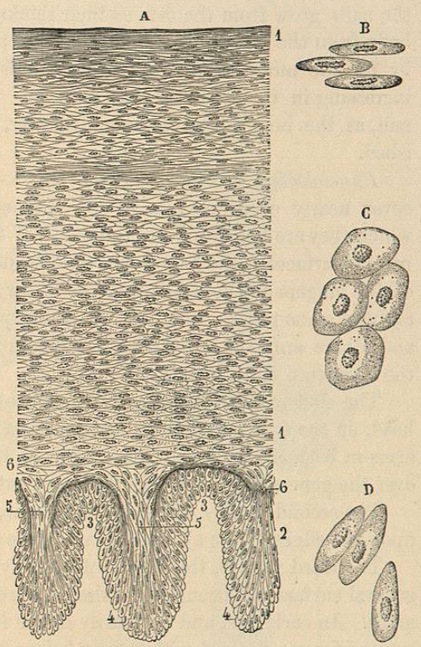

FIG. 106.—*Section of the nail etc.* (Sappey).

A, section of the nail: 1, 1, superficial layer; 2, deep layer; 3, 3, 4, 4, section of the grooves on the attached surface; 5, 5, union of the superficial with the deep layer; 6, 6, dark line between the two layers.
B, cells of the superficial layer, lateral view.
C, cells of the superficial layer, flat view.
D, cells of the deep layer.

One of the most striking peculiarities of the nails is their mode of

growth. The Malpighian layer is stationary, but the horny layer is constantly growing, if the nails be cut, from the root and bed. It is evident that the nails grow from the bed, as their thickness progressively increases in the body from the root to near the free border; but their longitudinal growth is by far the more rapid. Indeed, the nails are constantly pushing forward, increasing in thickness as they advance. Near the end of the body of the nail, as the horny layer becomes thinner, the growth from below is diminished.

Physiological Anatomy of the Hairs.—Hairs, varying greatly in size, cover nearly every portion of the cutaneous surface. The only parts in which they are not found are the palms of the hands and soles of the feet, the palmar surfaces of the fingers and toes, the dorsal surfaces of the last phalanges of the fingers and toes, the lips, the upper eyelids, the lining of the prepuce and the glans penis. Some of the hairs are long, others are short and stiff, and others are fine and downy. These differences have led to a division of the hairs into three varieties:

The first variety includes the long, soft hairs, which are found on the head, on the face in the adult male, around the genital organs and under the arms in both the male and the female, and sometimes upon the breast and over the general surface of the body and extremities, particularly in the male.

The second variety, the short, stiff hairs, is found just within the nostrils, upon the edges of the eyelids and upon the eyebrows.

The third variety, the short, soft, downy hairs, is found on parts of the general surface not occupied by the long hairs, and in the caruncula lachrymalis. In early life, and ordinarily in the female at all ages, the trunk and extremities are covered with downy hairs; but in the adult male, these frequently become developed into long, soft hairs.

The hairs are usually set obliquely in the skin and take a definite direction as they lie upon the surface. Upon the head and face, and, indeed, the entire surface of the body, the general course of the hairs may be followed out, and they present currents or sweeps that have nearly always the same directions in different persons.

The diameter and length of the hairs are variable in different persons, especially in the long, soft hairs of the head and beard. It may be stated in general terms that the long hairs attain the length of twenty inches to three feet (500 to 900 mm.) in women, and considerably less in men. Like the nails, the hair, when left to itself, attains in three or four years a definite length, but when it is habitually cut it grows constantly. The short, stiff hairs are $\frac{1}{4}$ to $\frac{1}{2}$ of an inch (6·4 to 12·7 mm.) in length. The soft, downy hairs measure ordinarily $\frac{1}{12}$ to $\frac{1}{2}$ of an inch (2·1 to 12·7 mm.) in length.

Of the long hairs, the finest are upon the head, where they average about $\frac{1}{400}$ of an inch (64 μ) in diameter. The hair ordinarily is coarser in women than in men. Dark hair is generally coarser than light hair; and upon the same head the extremes of variation are sometimes observed. The hairs of the beard and the long hairs of the body are coarser than the hairs of the

head. The average number of hairs upon a square inch of the scalp is about 1,000 (155 in a square centimetre) and the number upon the entire head, about 120,000 (Wilson).

When the hairs are in a perfectly normal condition, they are very elastic and may be stretched to one-fifth or one-third more than their original

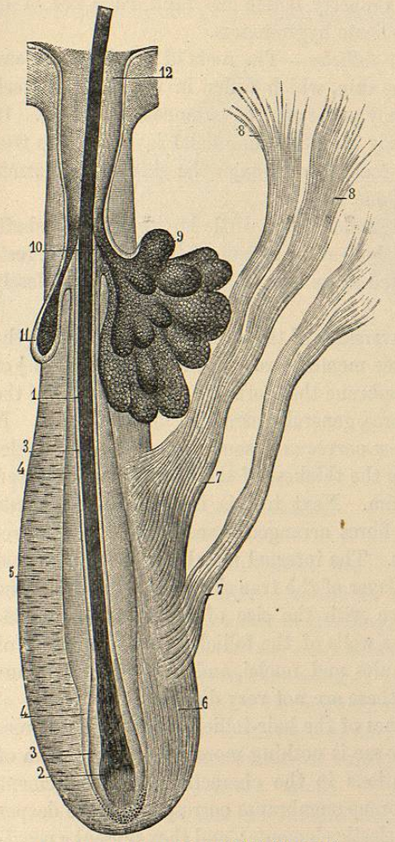

FIG. 107.—*Hair and hair-follicle* (Sappey).

1, root of the hair; 2, bulb of the hair; 3, internal root-sheath; 4, external root-sheath; 5, membrane of the hair-follicle (the internal, amorphous membrane of the follicle is very delicate and is not represented in the figure); 6, external membrane of the follicle; 7, 7, muscular bands attached to the follicle; 8, 8, extremities of these bands passing to the skin; 9, compound sebaceous gland, with its duct (10) opening into the upper third of the follicle; 11, simple sebaceous gland; 12, opening of the hair-follicle.

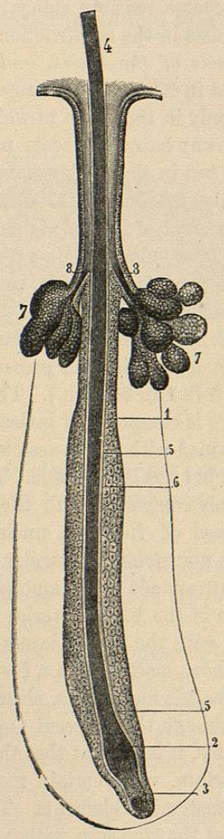

FIG. 108.—*Root of the hair* (Sappey).

1, root of the hair; 2, hair-bulb; 3, papilla of the follicle; 4, opening of the follicle; 5, 5, internal root-sheath; 6, external root-sheath; 7, 7, sebaceous glands; 8, 8, excretory ducts of the sebaceous glands.

length. Their strength varies with their thickness, but an ordinary hair from the head will bear a weight of six to seven ounces (170 to 200 grammes). A well known property of the hair is that of becoming strongly electric by